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NBS TECHNICAL NOTE 1165

U.S. DEPARTMENT OF COMMERCE/National Bureau of Standards

A Thermodynamic Surface for the Critical Region of Ethylene

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A Thermodynamic Surface for the Critical Region of Ethylene

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Issued October 1982

I

National Bureau of Standards Technical Note 1165
Natl. Bur. Stand. (U.S.), Tech. Note 1165, 85 pages (Oct. 1982)
CODEN: NBTNAE

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1982

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price $5.00
(Add 25 percent for other than U.S. mailing)

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A Thermodynamic Surface for the Critical Region of Ethylene[1]

by

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Tables are presented of thermodynamic properties of ethylene in the range 279-300 K in temperature, 5.75 - 10.5 mol/dm^3 in density, which range includes the critical point. The tables presented here are based on the critical-point scaling laws and incorporate the critical anomalies in a proper fashion. The tables thus complement the formulation of the equation of state of fluid ethylene by McCarty and Jacobsen (NBS Tech. Note 1045, 1981) which does not claim accuracy near the critical point. The predictions of the present formulation are compared with four sets of recent PVT data, and with speed-of-sound data. Tables are presented of pressure, energy, enthalpy, entropy, specific heats and speed of sound as function of temperature along finely-spaced isochores. The computer program required for table generation is included. Even if the surface were perfect, the reliability of densities calculated at experimental pressures and temperatures of limited accuracy declines rapidly as the critical point is approached. Contour plots in P-T space are presented of regions to be avoided in custody transfer for given uncertainties in pressure, temperature and sample composition.

Key words: critical region; custody transfer; density; enthalpy; ethylene; equation of state; impurity; scaling laws; specific heat; speed of sound; tabular values; thermodynamic properties.

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[1]This work was part of a Joint Industry - Government project under the sponsorship of Celanese Chemical Company, Cities Service Company, Continental Oil Company, Gulf Research and Development, Mobil Chemical Company, Monsanto Polymers and Petrochemicals Company, Phillips Chemical Company, Union Carbide Corp. and the National Bureau of Standards.

1. Introduction

A formulation is presented of the thermodynamic behavior of ethylene in a region around the critical point extending from 5.75 to 10.5 mol/dm^3 in density and from 279 to 300 K in temperature. A correct formulation of this near-critical region is more urgent for ethylene than for most other fluids, because in the climatic conditions of the United States the fluid transported in pipes can assume states located in this region. It is well recognized that most engineering equations of state are deficient in representing near-critical states [1,2]. Our formulation of the thermodynamic behavior of ethylene derives from a thermodynamic potential which obeys the critical-point scaling laws; it contains a first correction to scaling and also a revision to scaling designed to accommodate the lack of symmetry of the gas-liquid phase transition. The adjustable parameters in the potential were obtained by a fit to the PVT data of Hastings et al. [3] and to the speed-of-sound data of Gammon [4]. The advantage of our formulation is that the critical anomalies that are common to all fluids are properly incorporated. For instance, the flatness of the critical isotherm, which is hard to describe by analytic equations of state, is built into our potential. Its strength is particularly striking when it comes to representing the specific heat at constant volume, C_v, and the speed of sound, C_s. The weak divergence of C_v cannot be described by analytic free energy surfaces. This divergence, however, causes the speed of sound to approach the value zero at the critical point, a feature properly incorporated in our potential. The excellent speed-of-sound data of Gammon therefore form a crucial test for the adequacy of our thermodynamic surface. We stress that, by the use of so-called parametric variables, we have closed-form expressions for all thermodynamic properties.

We will describe how our potential is constructed, and proceed to compare it with recent experimental PVT data from three sources and with vapor pressures and coexisting densities from two sources. Comparisons are also made with the predictions of the global equation of state of ethylene recently published by McCarty and Jacobsen [5]. From these comparisons it will be evident that our potential will serve as a useful and necessary supplement in a region where the global equation is essentially deficient. In appendices, we present the equations defining our potential and a comparison of all data points mentioned above with the predictions of our surface. A table of the thermodynamic properties pressure, energy, entropy, enthalpy, specific heats C_p and C_v and speed of sound C_s, is presented along finely-spaced isochores with temperature as an entry. A table of saturation properties is included. The computer programs for generation of these tables are included. They contain an inversion routine which permits transformation from pressure to density as an independent variable.

For the convenience of the user concerned with custody transfer, we conclude the main body of the paper with a discussion of the uncertainties introduced in the density calculated from our surface due to limited precision in the measurement of pressure and temperature, and due to the presence of impurity. Contour plots in P-T space indicating regions in PT space to be avoided if a certain precision in density is desired, are included in this paper. Our work has been part of a joint industry-U.S. Government project to determine the thermodynamic properties of ethylene.

2. Fundamental Equation

At a critical point, thermodynamic behavior is anomalous. The critical point is characterized by the facts that the compressibility $K_T = -(1/V)(\partial V/\partial P)_T$ and the specific heat C_p diverge and the coexisting densities ρ_ℓ, ρ_v becomes equal. We write, asymptotically near the critical point

$$K_T^* = \Gamma|\Delta T^*|^{-\gamma} ,$$
$$\Delta\rho^* = B|\Delta T^*|^{\beta} . \qquad (1)$$

Here asterisks denote reduced properties, while $\Delta T^* \equiv (T-T_c)/T_c$ and $\Delta\rho^* \equiv (\rho_\ell-\rho_v)/2\rho_c$. The critical exponent γ equals 1, β equals 1/2 for classical equations of state of the type of Van der Waals' equation. In real fluids, γ equals about 1.24 and β is of the order 1/3. The critical-point scaling laws are constructed so that they yield the correct critical exponents; although one can define as many critical exponents as one sees fit, only two of them are independent. Their values are given by theory and they are the same for all fluids.

Our fundamental equation incorporates the scaling laws. The thermodynamic potential used in our work is that introduced by Ley-Koo and Green [6]. It is the dependent variable $\tilde{P} = P^*/T^*$ as a function of $\tilde{\mu} = \mu^*/T^*$ and $\tilde{T} = -1/T^*$. Here P is the pressure, μ is the chemical potential and T the absolute temperature. Asterisks denote reduced properties: $P^* = P/P_c$, $T^* = T/T_c$ and $\mu^* = \mu\rho_c/P_c$, where P_c is the critical pressure, T_c the critical temperature and ρ_c the critical density. In terms of this potential, we have

$$(\partial\tilde{P}/\partial\tilde{T})_{\tilde{\mu}} = \tilde{U} ,$$
$$(\partial\tilde{P}/\partial\tilde{\mu})_{\tilde{T}} = \tilde{\rho} , \qquad (2)$$

where $\tilde{U}$ is the reduced energy density $\tilde{U} = U^*/V^*$ and $\tilde{\rho}$ the reduced mass density, while the other thermodynamic functions: Helmholtz energy density $\tilde{A} = A^*/V^*$, enthalpy density $\tilde{H} = H^*/V^*$ and entropy density $\tilde{S} = S^*/V^*$ follow from

$$\tilde{A} = \tilde{\rho}\,\tilde{\mu} - \tilde{P} ,$$
$$\tilde{H} = \tilde{P} - \tilde{U}\,\tilde{T} , \qquad (3)$$
$$\tilde{S} = \tilde{H} - \tilde{\rho}\,\tilde{\mu} .$$

Since all variables are intensive, the coexistent phases collapse onto a curve, which, in the $\tilde{\mu}$, $\tilde{T}$ plane, can be parametrized by the analytic relation

$$\tilde{\mu}_o(\tilde{T}) = \tilde{\mu}_c + \Sigma\,\tilde{\mu}_j\,\Delta\tilde{T}^j ,$$

where $\Delta\tilde{T} = (T-T_c)/T$. In scaling, the physical variables $\tilde{\mu}$, $\tilde{T}$ are transformed to a new coordinate system, one axis of which is the curve $\tilde{\mu}_o(\tilde{T})$, while the other intersects the first at the critical point. The two scaling variables are linear combinations of $\tilde{\mu}-\tilde{\mu}_o$ and $\Delta\tilde{T}$:

$$u_\mu = \tilde{\mu}(\tilde{T}) - \tilde{\mu}_o(\tilde{T}) = \Delta\tilde{\mu}/a \ ,$$

$$u_t = \Delta\tilde{T} + c\,\Delta\tilde{\mu} \ , \qquad (4)$$

where a is a constant related to the scale of $\tilde{\mu}$. The term $c\Delta\mu$ breaks the liquid-vapor symmetry.

The potential $\tilde{P}$ is decomposed into two parts, one part, $\tilde{P}_{reg}$, that is regular in the scaling variables and one, $\Delta\tilde{P}$, that contains the critical anomalies with correct power-law dependence. We have assumed for $\tilde{P}_{reg}$:

$$\tilde{P}_{reg} = \tilde{P}_o(\tilde{T}) + \Delta\tilde{\mu} + P_{11}\,\Delta\tilde{\mu}\,\Delta\tilde{T} \ ,$$

$$P_o(\tilde{T}) = 1 + \sum_{j=1} P_j\,(\Delta\tilde{T})^j \ . \qquad (5)$$

$\Delta\tilde{P}$, in scaled form, is given by

$$\Delta\tilde{P} = ak_o|u_t|^{2-\alpha}\ g_o\left(\frac{u_\mu}{|u_t|^{\beta\delta}}\right) + ak_1|u_t|^{2-\alpha+\Delta_1}\ g_1\left(\frac{u_\mu}{|u_t|^{\beta\delta}}\right) \qquad (6)$$

The first term represents asymptotic scaling, the second a correction to scaling. The critical exponents α,β,δ are those characterizing the divergence of the specific heat at constant volume C_v, the shape of the coexistence curve, and the shape of the critical isotherm, respectively. The leading term contains one more adjustable constant k_o, while the function g_o is universal, i.e., the same for all fluids. The correction term contains a new independent critical exponent Δ_1, also given by theory, and a new free constant k_1. The function g_1 is the same for all fluids.

All thermodynamic functions can be given in algebraically closed form by the device of transformation to parametric variables [7]

$$\Delta\tilde{\mu} = au_\mu = r^{\beta\delta}\,a\,\theta\,(1-\theta^2) \ ,$$

$$u_t = r\,(1-b^2\theta^2) \qquad (7)$$

The variable r measures "distance from the critical point", while θ is measured along a contour of constant r. θ reaches the values ± 1 on the phase boundary; b^2 is a constant predicted to be universal. The critical anomalies are all imbedded in the r-dependence while the dependence of the thermodynamic functions on θ is always in the form of simple polynomials or their ratios. All relevant equations are given in Appendix A. Note that the functions are listed separately for the one- and two-phase regions.

The constants defining our potential were obtained as follows. The critical exponent values $\alpha,\beta,\gamma,\delta,\Delta_1$ are those predicted by theory [8]. The critical parameters, the five parameters in the scaling function: a, k_o, k_1, c, b^2 and the four "background" parameters

$\tilde{P}_1$, $\tilde{P}_2$, $\tilde{P}_3$ and $\tilde{P}_{11}$ were determined by a fit to the PVT data of Hastings et al. [3], while we imposed the condition that the slope of the vapor pressure curve at the critical point be that of the vapor pressure data of Levelt Sengers and Hastings [9], that the critical point lie on the vapor pressure curve and that the diameter of the coexistence curve be that measured by Douslin and Harrison [10]. This implies that the values of T_c and P_c are constrained to be on the vapor pressure curve and cannot be fitted independently. Two background parameters $\tilde{\mu}_2$,$\tilde{\mu}_3$ were determined by a fit to the speed-of-sound data of Gammon [4]. The other two, $\tilde{\mu}_c$ and $\tilde{\mu}_1$, are related to the zeros for energy, entropy and enthalpy, and were fixed by tying the surface to that of McCarty and Jacobsen [5] at one point, 298.15 K and 6 mol/dm^3. The parameters characterizing our potential are listed in Table I. The range of validity of the potential is indicated in Fig. 1.

3. The Equation of State

We compare the predictions of our potential for the equation of state of ethylene with experiment. The experimental data are those of Hastings et al. [3] for a 99.993% pure sample, to which the potential was fitted, those of Douslin and Harrison [10], Trappeniers et al. [11] and Thomas and Zander [12,13]. Older data have been adequately reviewed in the IUPAC formulation of Angus et al. [14], and in the reviews of Date [15] and Vashchenko [16].

The potential represents the data of Hastings et al. with a reduced chi-square of 1.3 if the uncertainties are estimated as 5×10^{-5} MPa in pressure, 3×10^{-3} mol/dm^3 in density and 5×10^{-4} K in temperature. It is to be kept in mind that our data were fitted to these close tolerances even though the deviation plots of Figs. 2-13 show occasionally large density deviations. The percentage differences in density between the data and our surface, assuming the pressures to be the same, and, alternatively, the percentage differences in pressure, assuming the densities to be the same, are shown for the various isotherms in Figs. 2-13. At 298.15K (Fig. 2) the surface represents our own data to well within 0.1% in density. The agreement between the data sets of [3], [10] and [11] is almost within the 0.1% tolerance originally set as a goal for the U.S. Government - Industry joint project on properties of ethylene. The data set of Thomas and Zander [12,13] shows considerably more scatter than the other three sets, without, however, showing systematic departures from our formulation. The pressure deviations are similarly small at this temperature, with a tendency to grow in the highly compressed fluid, as is to be anticipated [Fig. 3]. When the critical point is approached, the density departures between the data sets, and their departures from the surface, increase dramatically, while the pressure deviations remain more or less the same (Figs. 4-10). At the temperatures from 0.7-3.7 K above the critical temperature, the density departures reach values larger than 0.5% and on isotherms spanning the critical the largest departure is 15%. The pressure deviations, however, remain as well-behaved as at 298.15K if not better, the departures being of the order of 0.02% in the range around critical (Figs. 11-13). This is a good illustration of the difference between "density" and "field" variables in the vicinity of a critical point. ("Density" variables are those that are different in coexisting phases while "field" variables are the same.) Due to the strong divergences of the compressibility and expansion coefficients, small

systematic differences in temperature and pressure scales between the various laboratories are amplified when the densities are compared. Furthermore, the effect of impurity is largest at the critical point, and small differences in sample composition can lead to large variations in density.

A study of the plots Figs. 2-13 will convince the reader that most of the region covered in this report should be avoided if an accuracy of 0.1% in density is desired in custody transfer. Even if our surface were perfect, the finite precision of industrial pressure and temperature measurement will result in large errors if the density is calculated from the equation of state.

Appendix B, Table II, contains the deviations of the PVT data sets [3], [10], [11], [12], [13] and [14] from the present formulation.

4. Coexistence Properties

Vapor pressures from 279.15 K to the critical temperature are compared in Fig. 14. Data sources are those of Levelt Sengers and Hastings [9] and those of Douslin and Harrison [10]. These two data sets were shown to agree within combined error of 10^{-4} MPa at temperatures below 240 K [9]; the departures are systematic at higher temperatures, and reach a maximum of 7×10^{-4} MPa at the critical point. A satisfactory explanation for the difference has not been given. It is larger than expected on the basis of the agreement of pressure scales (1 in 20,000) and temperature scales (1 mK) and not quite of the form expected for a difference in purity [7]. Nevertheless, the agreement between the data sets [9] and [10], better than 2 parts in 10^4, is an order better than that between these sets and the older data (cf. [10], p. 311). Table III in Appendix B contains the deviations of the vapor pressures data sets [9] and [10] from our formulation.

Coexisting densities of Refs. [3] and [10] are compared with our formulation in Fig. 15. The agreement between the two data sets and the formulation, to ± 0.02 mol/dm^3, is satisfactory in this region close to the top of the coexistence dome.

5. Speed of Sound

As we mentioned before, we determined the parameters $\tilde{\mu}_2$, $\tilde{\mu}_3$ in our potential from a fit to Gammon's speed-of-sound data [4], accepting his density and temperature values as independent variables. It should be stressed that the anomalous contribution to the speed of sound that drives speed of sound to zero at the critical point has been completely predicted from the part of the potential that was determined by the PVT data alone. A substantial loss of accuracy is to be expected when second derivatives are calculated from the potential. We therefore consider the result of our procedure, a prediction of the speed of sound that is generally well within 1% from experiment, as very satisfactory. A global view of the speed of sound within the range of our correlation is shown in Fig. 16. Fig. 17 shows the departures of the speed of sound from our surface. It should be mentioned that we had to omit a few of Gammon's data points because our surface predicted them to be inside the two-phase region. Also, we omitted the data points on the critical isotherm within $\pm$ 10% from the

critical density, these points being heavily affected by dispersion.

Fig. 16 and 17 reveal one defect of our model: on subcritical isotherms, the speed of sound, instead of continuing to fall as the phase boundary is approached, passes through a minimum and then experiences a minute increase in the last percent of density from coexistence. We believe this behavior to be unphysical. It was not present when we fitted our potential to the experimental data for steam. We have, however, not been able to eliminate this artifact by the device of clamping more tightly on the PVT data near the phase boundary, nor by reducing the range of the fit. It is likely that speed-of-sound data of the quality of [4] may contain more information than even high-quality PVT data; it would be interesting to use the sound data to determine some of the parameters in the scaled part of the potential.

Table IV in Appendix B contains a listing of the departures of the experimental data from the present formulation.

6. Other Formulations

A recent comprehensive correlation of the properties of ethylene, in the form of an equation of state based on the same data sets considered in this paper, is that of McCarty and Jacobsen [5]. It was preceded by several other correlations, two of which we will consider here: the IUPAC formulation by Angus et al. [14], which formulation is based on a part-graphical, part-analytic representation of the PVT properties of ethylene obtained prior to 1972; and the correlation obtained by graphical means by Harrison and Douslin [7] of their own data. The solid curves in Figs. 2-13 indicate the departures of the McCarty - Jacobsen formulation from our own. Since the Helmholtz function of McCarty and Jacobsen is analytic, it has difficulty representing the flatness of near-critical isotherms, as was recognized by the authors. At 298.15 K the departures, though systematic, are limited to a maximum of 0.3% in density, but as the temperature approaches the critical the departures become more severe. At temperatures within 1 K from critical where our formulation agrees with all data to well within 0.1% in pressure, the McCarty-Jacobsen formulation departs by several tenths of a percent in pressure in a systematic fashion. These differences are magnified when derived properties are considered. An example is shown in Fig. 17 for the enthalpy of ethylene, where enthalpies according to three formulations are compared along the 283.15 K, 288.15 K, and 298.15 K isotherms. The graphical method of Harrison and Douslin, if applied with care to excellent data, should be expected to give better results than can be obtained with a fit to an empirical thermodynamic surface that is seldom quite true to the data. A possible exception is the near-critical regime: The anomalous curvature of isochores may be missed by graphical techniques and by analytic surface alike, but is correctly incorporated in our potential. The intercomparison in Fig. 18 shows that the Harrison and Douslin enthalpies show no density-dependent departures from our surface and have, therefore, been very carefully evaluated. At 298.15 K the offset is about 8 J/mol and could have been eliminated had we tied our enthalpy at 298.15 K, 6 mol/dm^3 to that of Harrison and Douslin, rather than to that of McCarty and Jacobsen. At the other two temperatures a systematic offset of 20 J/mol is observed. We do not know why a 12 J/mol enthalpy difference is picked up between 298.15 and 288.15 K.

At 298.15 K our enthalpies agree closely with those of McCarty and Jacobsen, but the density dependence of the two formulations is different. Increasing departures build up as the critical point is approached.

The departures of the IUPAC formulations show strong systematic trends. This formulation was based on older data and was never claimed to possess high quality in the critical region.

First and second derivatives according to the McCarty - Jacobsen formulation are compared with our own in Figs. 19, 20. The first derivatives U, H and S have somewhat different density dependence in the two formulations. Moreover, appreciable departures build up around the critical density and near the critical temperature. The departures of C_p, C_v and the speed of sound are substantial. They are about 1% at 298.15 K, 5 - 10%, at 288.15 K and 20 - 40% at 283.15 K (0.8 K above critical). An analytic representation cannot describe the divergence of C_v and the accompanying decline to zero of the (thermodynamic) speed of sound while the divergence of C_p is not strong enough; so these large departures are not surprising. The authors themselves did not claim accuracy in the critical region. Since we have represented the speed-of-sound data to about 1% in accuracy, we are confident that our model represents thermodynamic behavior, such as a weakly diverging C_v, accurately.

7. The Effect of Pressure and Temperature Errors on Density

In custody transfer, the density of ethylene will be calulated from its measured pressure and temperature. Since these quantities are measured with limited accuracy, an error in density will result that is given by

$$\frac{\delta\rho}{\rho} = (PK_T)\,\frac{\delta P}{P} \quad , \tag{8}$$

or

$$\frac{\delta\rho}{\rho} = -\alpha_p\,\delta T = -K_T\,\left(\frac{\partial p}{\partial T}\right)_v\,\delta T \, . \tag{9}$$

In view of the strong divergence of the compressibility K_T and the expansion coefficient α_p, the density error resulting from inaccuracy in the measurement of P or T is a maximum at the critical point. We show the region in P-T space that should be avoided if an accuracy of 0.1% in density is desired and the pressure is measured with an accuracy of 0.1, 0.05 and 0.02%, respectively, (Fig. 21); or the temperature is measured to 0.02, 0.01 or 0.005 K, respectively, (Fig. 22).

8. The Effect of Impurity on Density

The present formulation of the equation of state of ethylene is based on the PVT data obtained for 99.993% pure ethylene, with ethane as the prime impurity. The formulation permits the calculation of the density of an ethylene sample from its pressure and temperature. If impurities are present in the sample of interest, the predicted density will differ from the actual one. It is of interest to know what effect a known impurity has on density, and how the effect varies with the temperature and pressure.

Under simplifying assumptions, this question can be answered. We will assume that the impure fluid is in corresponding states with the pure host, and that the impure system

displays pseudo-critical constants that are shifted from those of the pure host by amounts linear in concentration:

$$T_{xc} = T_c\,(1 + ax)\ ,$$
$$P_{xc} = P_c\,(1 + bx)\ ,$$
$$V_{xc} = V_c\,(1 + (a-b)x)\ . \qquad (10)$$

Both assumptions are reasonable and readily justifiable in dilute mixtures; the only difficulty with the model is the actual assignment of the values of a and b, parameters characteristic of the host-impurity interaction. They can be determined from the critical parameters of the pure components in the case that the critical points are connected by a continuous critical line. For the sake of developing our estimate of the density error introduced by impurity, we will consider these parameters a,b as known.

An equation for the impurity-induced density error was derived by us [3]. It was obtained by applying the law of corresponding states to the pure host and the dilute mixture at the same pressure and temperature. The following result was obtained for the change in density:

$$\frac{\delta\rho}{\rho} = -x[(a-b) + b\,PK_T - aT\alpha_p]$$
$$= -x[(a-b) + bPK_T - a(PK_T)\,(\frac{T}{P}\frac{\partial P}{\partial T})]\ , \qquad (11)$$

where K_T is the compressibility, α_p the expansion coefficient of the pure host at T, P. It is clear that Eq. (11) permits calculation of the impurity-induced error in density at any point in P-T space once the constants a, b are known. The relation (11) should not be applied too close to the critical point since the coefficient of the term in x diverges. More seriously, an expansion in x has as little justification as one in ρ, which is known to be invalid at the critical point.

A scrutiny of Eq. (11) immediately reveals that impurity-induced density errors will be largest near the critical point. This is a consequence of the fact that both K_T and α_p diverge strongly at this point. The precise nature of this density error will, of course, depend on the values of a and b. Since these values form the most controversial part of our model, we will consider only a few extreme cases.

(1) a = -.5, b = 0: a highly volatile impurity that depresses the critical temperature of the mixture strongly without affecting the critical pressure.

(2) a = .5, b = 0: a highly nonvolatile impurity that increases the critical temperature of the mixture strongly without affecting the critical pressure.

The cases (1) and (2) have opposite effects on the density. The impurity-induced density error is given by

$$\frac{\delta\rho}{\rho} = \pm 0.5 \times [1 - (P\,K_T)\,(\frac{T}{P}\frac{\partial P}{\partial T})] \qquad (5)$$

where the + sign refers to case 1, the - sign to case 2. In Fig. 23, we show the region in P-T space that should be avoided in custody transfer if an accuracy in density of 0.1% is desired and if various amounts of an impurity very different in volatility from ethylene are present.

9. Tables of Thermodynamic Properties

In Appendix C we present the thermodynamic properties of ethylene in the critical region. It was not possible to organize this table along isobars, as in [5]. The extremely rapid variation of the "density"-like properties ρ, U, H, S with P and T would preclude interpolation in such a table. We have therefore tabulated the properties along isochores, or at constant density, using temperature as the second entry (Table V). In addition, we present tables of saturation properties first with temperature, then with pressure as an entry (Table VI, VII).

The computer program required for the generation of thermodynamic properties of ethylene is listed in Appendix D. Appendix E contains units and conversion factors.

Acknowledgements

R.D. McCarty and B.E. Gammon provided us with results of their work prior to publication.

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Table I. Parameters in the Thermodynamic Potential for Ethylene

Critical Exponents (fixed)	$\beta = 0.325$
	$\delta = 4.82$
	$\Delta_1 = 0.50$
Critical Parameters	$T_c = 282.3452$
	$\rho_c = 7.634$ mol/dm^3
	$P_c = 5.0403$ MPa (derived)
Parameters in Scaling Function	$a = 23.9809$
	$k_0 = 1.37617$
	$k_1 = 0.7662$
	$c = -0.007833$
	$b^2 = 1.67472$
Pressure background parameters	$\tilde{P}_1 = 5.3439$
	$\tilde{P}_2 = -16.9686$
	$\tilde{P}_{11} = -0.181762$ (derived)
Caloric background parameters	$\tilde{\mu}_0 = -36.4812$
	$\tilde{\mu}_1 = -27.35945$
	$\tilde{\mu}_2 = -12.5003$
	$\tilde{\mu}_3 = -10.5742$

APPENDIX A: Revised and Extended Scaling Equations for the Thermodynamic Properties of Fluids.

A.1 Reduced thermodynamic quantities

$$\tilde{T} = \frac{T_c}{T} \quad , \quad \tilde{\mu} = \frac{\mu}{T} \cdot \frac{\rho_c T_c}{P_c} \quad , \quad \tilde{P} = \frac{P}{T} \cdot \frac{T_c}{P_c} \quad ,$$

$$\tilde{\rho} = \frac{\rho}{\rho_c} \quad , \quad \tilde{U} = \frac{U}{V} \cdot \frac{1}{P_c} \quad , \quad \tilde{S} = \frac{S}{V} \cdot \frac{T_c}{P_c} \quad , \tag{A.1}$$

$$\tilde{A} = \frac{A}{VT} \cdot \frac{T_c}{P_c} \quad , \quad \tilde{H} = \frac{H}{VT} \cdot \frac{T_c}{P_c} \quad , \quad \tilde{\chi}_T = \left(\frac{\partial \tilde{\rho}}{\partial \tilde{\mu}}\right)_T \quad ,$$

$$\tilde{C}_v = \frac{C_v}{V} \frac{T_c}{P_c} \quad , \quad \tilde{C}_p = \frac{C_p}{V} \cdot \frac{T_c}{P_c}$$

(T is temperature, μ is chemical potential, P is pressure, ρ is density, U is energy, S is entropy, A is helmholtz free energy, H is enthalpy, V is volume, C_V is heat capacity at constant V, C_p is heat capacity at constant P).

A.2 Thermodynamic relations

$$d\tilde{P} = \tilde{U}d\tilde{T} + \tilde{\rho}d\tilde{\mu}$$

$$d\tilde{A} = -\tilde{U}d\tilde{T} + \tilde{\mu}d\tilde{\rho} \tag{A.2}$$

$$d\tilde{H} = -\tilde{T}d\tilde{U} + \tilde{\rho}d\tilde{\mu}$$

$$d\tilde{S} = -\tilde{T}d\tilde{U} - \tilde{\mu}d\tilde{\rho}$$

$$\tilde{A} = \tilde{\rho}\tilde{\mu} - \tilde{P}$$

$$\tilde{H} = \tilde{P} - \tilde{T}\tilde{U} \qquad \text{(A.3)}$$

$$\tilde{S} = \tilde{H} - \tilde{\rho}\tilde{\mu} = -\tilde{T}\tilde{U} - \tilde{A}$$

A.3 Fundamental equations

$$\Delta\tilde{T} = \tilde{T} + 1 \qquad \text{(A.4a)}$$

$$\Delta\tilde{\mu} = \tilde{\mu} - \tilde{\mu}_o(\tilde{T}) \qquad \text{(A.4b)}$$

$$\tilde{P} = \tilde{P}_o(\tilde{T}) + \Delta\tilde{\mu} + \tilde{P}_{11}\Delta\tilde{\mu}\Delta\tilde{T} + \Delta\tilde{P} \qquad \text{(A.5)}$$

with

$$\tilde{\mu}_o(\tilde{T}) = \tilde{\mu}_c + \sum_{j=1}^{3} \tilde{\mu}_j (\Delta\tilde{T})^j \qquad \text{(A.6a)}$$

$$\tilde{P}_o(\tilde{T}) = 1 + \sum_{j=1}^{3} \tilde{P}_j (\Delta\tilde{T})^j \qquad \text{(A.6b)}$$

A.4 Derived thermodynamic quantities

$$\tilde{\rho} = 1 + \tilde{P}_{11}\Delta\tilde{T} + \left(\frac{\partial\Delta\tilde{P}}{\partial\Delta\tilde{\mu}}\right)_{\Delta\tilde{T}} \qquad \text{(A.7)}$$

$$\tilde{U} = \frac{d\tilde{P}_o}{d\tilde{T}} - \rho\frac{d\tilde{\mu}_o}{d\tilde{T}} + \tilde{P}_{11}\Delta\tilde{\mu} + \left(\frac{\partial\Delta\tilde{P}}{\partial\Delta\tilde{T}}\right)_{\Delta\tilde{\mu}} \qquad \text{(A.8)}$$

$$\tilde{\chi}_T = \left(\frac{\partial^2\Delta\tilde{P}}{\partial\Delta\tilde{\mu}^2}\right)_{\Delta\tilde{T}} \qquad \text{(A.9)}$$

$$\left(\frac{\partial\tilde{P}}{\partial\tilde{T}}\right)_{\tilde{\rho}} = \frac{d\tilde{P}_o}{d\tilde{T}} + \tilde{P}_{11}\left[\Delta\tilde{\mu} - \frac{\tilde{\rho}}{\tilde{\chi}_T}\right] + \left(\frac{\partial\Delta\tilde{P}}{\partial\Delta\tilde{T}}\right)_{\Delta\tilde{\mu}} - \frac{\tilde{\rho}}{\tilde{\chi}_T}\frac{\partial^2\Delta\tilde{P}}{\partial\Delta\tilde{\mu}\partial\Delta\tilde{T}} \qquad \text{(A.10)}$$

$$\frac{\tilde{C}_v}{\tilde{T}^2} = \frac{d^2\tilde{P}_o}{d\tilde{T}^2} - \tilde{\rho}\frac{d^2\tilde{\mu}_o}{d\tilde{T}^2} - \frac{\tilde{P}_{11}^2}{\tilde{\chi}_T} +$$

$$+ \left(\frac{\partial^2\Delta\tilde{P}}{\partial\Delta\tilde{T}^2}\right)_{\Delta\tilde{\mu}} - \frac{2\tilde{P}_{11}}{\tilde{\chi}_T}\frac{\partial^2\Delta\tilde{P}}{\partial\Delta\mu\partial\Delta\tilde{T}} - \frac{1}{\tilde{\chi}_T}\left(\frac{\partial^2\Delta\tilde{P}}{\partial\Delta\tilde{\mu}\partial\Delta\tilde{T}}\right)^2 \qquad \text{(A.11)}$$

$$\tilde{C}_P = \tilde{C}_v + \frac{\tilde{\chi}_T}{\tilde{\rho}^2}\left[\tilde{P} - \tilde{T}\left(\frac{\partial\tilde{P}}{\partial\tilde{T}}\right)_{\tilde{\rho}}\right]^2 \qquad \text{(A.12)}$$

A.5 Critical exponents

$$\alpha_o = \alpha \quad , \qquad \alpha_1 = \alpha - \Delta_1$$

$$\beta_o = \beta \quad , \qquad \beta_1 = \beta + \Delta_1 \qquad \text{(A.13)}$$

$$\gamma_o = \gamma \quad , \qquad \gamma_1 = \gamma - \Delta_1$$

with

$$2 - \alpha = \beta(\delta+1) \quad , \qquad \gamma = \beta(\delta-1) \qquad \text{(A.14)}$$

A.6 Parametric equations for singular terms

$$\Delta\tilde{\mu} = r^{\beta\delta}a\theta(1-\theta^2) \qquad \text{(A.15)}$$

$$\Delta\tilde{T} = r(1-b^2\theta^2) - c\Delta\tilde{\mu} \qquad \text{(A.16)}$$

$$\Delta\tilde{P} = \sum_{i=0}^{1} r^{2-\alpha_i} a k_i p_i(\theta) \tag{A.17}$$

$$\left(\frac{\partial \Delta\tilde{P}}{\partial \Delta\tilde{\mu}}\right)_{\Delta\tilde{T}} = \sum_{i=0}^{1} \left[r^{\beta_i} k_i \theta + c r^{1-\alpha_i} a k_i s_i(\theta)\right] \tag{A.18}$$

$$\left(\frac{\partial \Delta\tilde{P}}{\partial \Delta\tilde{T}}\right)_{\Delta\tilde{\mu}} = \sum_{i=0}^{1} r^{1-\alpha_i} a k_i s_i(\theta) \tag{A.19}$$

$$\left(\frac{\partial^2 \Delta\tilde{P}}{\partial \Delta\tilde{\mu}^2}\right)_{\Delta\tilde{T}} = \sum_{i=0}^{1} \left[r^{-\gamma_i} \frac{k_i}{a} u_i(\theta) + 2c r^{\beta_i - 1} k_i v_i(\theta) + c^2 r^{-\alpha_i} a k_i w_i(\theta)\right] \tag{A.20}$$

$$\frac{\partial^2 \Delta\tilde{P}}{\partial \Delta\tilde{\mu} \Delta\tilde{T}} = \sum_{i=0}^{1} \left[r^{\beta_i - 1} k_i v_i(\theta) + c r^{-\alpha_i} a k_i w_i(\theta)\right] \tag{A.21}$$

$$\left(\frac{\partial^2 \Delta\tilde{P}}{\partial \Delta\tilde{T}^2}\right)_{\Delta\tilde{\mu}} = \sum_{i=0}^{1} r^{-\alpha_i} a k_i w_i(\theta) \tag{A.22}$$

A.7 Auxiliary functions

$$p_i(\theta) = p_{oi} + p_{2i}\theta^2 + p_{4i}\theta^4 \tag{A.23}$$

$$s_i(\theta) = s_{oi} + s_{2i}\theta^2 \quad , \quad s_i'(\theta) = 2 s_{2i}\theta \tag{A.24}$$

$$q(\theta) = 1 + \{b^2(2\beta\delta - 1) - 3\}\theta^2 - b^2(2\beta\delta - 3)\theta^4 \tag{A.25}$$

$$u_i(\theta) = [1 - b^2(1 - 2\beta_i)\theta^2]/q(\theta) \tag{A.26}$$

$$v_i(\theta) = [\beta_i(1 - 3\theta^2)\theta - \beta\delta(1 - \theta^2)\theta]/q(\theta) \tag{A.27}$$

$$w_i(\theta) = [(1-\alpha_i)(1-3\theta^2)s_i(\theta) - \beta\delta(1-\theta^2)\theta s_i'(\theta)]/q(\theta) \qquad (A.28)$$

with

$$p_{oi} = + \frac{\beta\delta - 3\beta_i - b^2\alpha_i\gamma_i}{2b^4(2-\alpha_i)(1-\alpha_i)\alpha_i}$$

$$p_{2i} = - \frac{\beta\delta - 3\beta_i - b^2\alpha_i(2\beta\delta-1)}{2b^2(1-\alpha_i)\alpha_i} \qquad (A.29)$$

$$p_{4i} = + \frac{2\beta\delta - 3}{2\alpha_i}$$

$$s_{oi} = (2-\alpha_i)p_{oi}$$

$$s_{2i} = - \frac{\beta\delta - 3\beta_i}{2b^2\alpha_i} \qquad (A.30)$$

A.8 Two-phase properties

Variables:

$$\theta = \pm 1$$

$$\Delta\tilde{\mu} = 0$$

$$\Delta\tilde{T} = r(1 - b^2) \qquad (A.31)$$

Vapor pressure:

$$\tilde{P}_{vap} = \tilde{P}_o(T) + \sum_{i=0}^{1} r^{2-\alpha_i} \; ak_i p_i(1) \qquad (A.32)$$

coexisting densities:

$$\frac{\tilde{\rho}_L+\tilde{\rho}_v}{2} = 1 + \tilde{P}_{11}\,\Delta\tilde{T} + \sum_{i=0}^{1} c\, r^{1-\alpha_i} a k_i s_i(1)$$

$$\frac{\tilde{\rho}_L-\tilde{\rho}_v}{2} = \sum_{i=0}^{1} r^{\beta_i} k_i \qquad \text{(A.33)}$$

helmholtz free energy:

$$\tilde{A} = \tilde{\rho}\,\tilde{\mu}_o(\tilde{T}) - \tilde{P}_o(T) - \sum_{i=0}^{1} r^{2-\alpha_i} a k_i p_i(1) \qquad \text{(A.34)}$$

energy:

$$\tilde{U} = \frac{d\tilde{P}_o}{d\tilde{T}} - \rho\frac{d\tilde{\mu}_o(T)}{d\tilde{T}} + \frac{1}{1-b^2} \sum_{i=0}^{1} (2-\alpha_i) r^{1-\alpha_i} a k_i p_i(1) \qquad \text{(A.35)}$$

entropy:

$$\tilde{S} = -\tilde{\rho}\,\tilde{\mu}_o(\tilde{T}) + \tilde{P}_o(\tilde{T}) - \tilde{T}\left[\frac{d\tilde{P}_o}{d\tilde{T}} - \rho\frac{d\tilde{\mu}_o}{d\tilde{T}}\right]$$

$$+ \sum_{i=0}^{1} r^{2-\alpha_i} a k_i p_i(1) - \frac{\tilde{T}}{1-b^2} \sum_{i=0}^{1} (2-\alpha_i) r^{1-\alpha_i} a k_i p_i(1) \qquad \text{(A.36)}$$

specific heat C_v:

$$\frac{\tilde{C}_v}{\tilde{T}^2} = \frac{d^2\tilde{P}_o}{d\tilde{T}^2} - \tilde{\rho}\frac{d^2\tilde{\mu}_o}{d\tilde{T}^2} + \left(\frac{1}{1-b^2}\right)^2 \sum_{i=0}^{1} (2-\alpha_i)(1-\alpha_i) r^{-\alpha_i} a k_i p_i(1) \qquad \text{(A.37)}$$

Appendix B. Comparison with Experiment

In Table II, the experimental PVT data are compared with the formulation (a) as pressure differences under the assumption that the densities are exact and (b) as density differences under the assumption that the pressures are exact. In Table III, saturation pressures and densities from two sources are compared with the formulation. In Table IV, the speed-of-sound data [4] are compared with the theoretical prediction. The density (DENS) is in mol/dm^3 and the speed of sound w in m/s. The legend for the various data sources is as follows

1 DH [10]
2A HLSB [3], 99.993% sample
2B HLSB [3], 99.999% sample
3 TWW [11],
4 TZ [13]

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Table II. Comparison of the experimental PVT data from four sources with the formulation

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
2A	298.1500	8.32377	8.31908	.056	10.542100	10.547447	-.051
2A	293.1500	7.33162	7.32880	.039	10.544600	10.548586	-.038
2A	289.1500	6.54857	6.54693	.025	10.546700	10.549579	-.027
2A	283.6500	5.49438	5.49414	.004	10.549500	10.550146	-.006
2A	282.3440	5.24955	5.24957	-.000	10.550200	10.550143	.001
2A	281.1393	5.02650	5.02643	.001	10.550600	10.551053	-.002
2A	280.6394	4.93481	4.93461	.004	10.551000	10.551927	-.008
2A	280.3394	4.88010	4.87976	.007	10.551200	10.552670	-.014
2A	280.0394	4.82562	4.82505	.012	10.551300	10.553901	-.025
2A	279.7394	4.77146	4.77051	.020	10.551500	10.556070	-.043
2A	298.1500	7.89748	7.89935	-.024	10.020900	10.021107	.028
2A	285.6500	5.68640	5.68744	-.018	10.029800	10.026154	.037
2A	283.6500	5.34587	5.34697	-.020	10.030900	10.025659	.052
2A	282.3440	5.12725	5.12824	-.019	10.031500	10.025416	.061
2A	281.1393	4.92924	4.92977	-.011	10.032100	10.027673	.044
2A	280.8393	4.88062	4.88086	-.005	10.032200	10.029998	.022
2A	280.7393	4.86455	4.86459	-.001	10.032300	10.031900	.004
2A	298.1500	7.46225	7.46412	-.025	9.285400	9.281344	.044
2A	293.1500	6.68170	6.68233	-.009	9.287600	9.285894	.021
2A	289.1500	6.06666	6.06664	.000	9.289400	9.289482	-.001
2A	285.6500	5.53899	5.53879	.004	9.290900	9.292384	-.016
2A	283.6500	5.24431	5.24431	-.000	9.291800	9.291775	.000
2A	282.3440	5.05644	5.05660	-.003	9.292400	9.288973	.037
2A	281.8393	4.98547	4.98552	-.001	9.292600	9.290874	.019
2A	281.7893	4.97849	4.97853	-.001	9.292600	9.291361	.013
2A	298.1500	7.29472	7.29582	-.015	8.910500	8.907691	.032
2A	293.1500	6.56545	6.56539	.001	8.912600	8.912840	-.003
2A	289.1500	5.99031	5.99065	.011	8.914300	8.918022	-.042
2A	285.6500	5.49642	5.49573	.013	8.915800	8.923084	-.082
2A	283.6500	5.22054	5.22022	.006	8.916700	8.923166	-.073
2A	282.3440	5.04511	5.04512	-.000	8.917200	8.916409	.009
2A	282.1893	5.02483	5.02482	.000	8.917300	8.917943	-.007
2A	282.0993	5.01308	5.01308	.000	8.917300	8.918628	-.015
2A	282.0949	5.01251	5.01249	.000	8.917300	8.918978	-.019
2A	282.0943	5.01246	5.01241	.001	8.917300	8.921296	-.045
2A	282.0936	5.01233	5.01232	.000	8.917300	8.918123	-.009
2A	282.0893	5.01181	5.01176	.001	8.917300	8.921527	-.047
2A	282.0891	5.01178	5.01173	.001	8.917300	8.919558	-.025
2A	282.0877	5.01153	5.01155	.000	8.917300	8.918114	-.009
2A	298.1500	7.23391	7.23474	-.011	8.757700	8.755431	.026
2A	283.6500	5.21398	5.21352	.007	8.763800	8.772971	-.105
2A	282.3440	5.04288	5.04289	-.000	8.764300	8.763615	.008
2A	282.2193	5.02695	5.02697	-.000	8.764300	8.762402	.022
2A	282.1916	5.02346	5.02345	.000	8.764400	8.766152	-.020
2A	282.1911	5.02344	5.02338	.001	8.764400	8.771465	-.081
2A	282.1909	5.02335	5.02336	-.000	8.764400	8.763508	.010
2A	282.1893	5.02316	5.02315	.000	8.764400	8.765213	-.009
2A	282.1798	5.02097	5.02080	.003	8.764400	8.784795	-.233

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Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
2A	303.1500	7.47281	7.47347	-.009	7.672200	7.670385	.024
2A	298.1500	6.88257	6.88269	-.002	7.674000	7.673568	.006
2A	293.1500	6.29461	6.29437	.004	7.675800	7.677184	-.018
2A	289.1500	5.82601	5.82639	.007	7.677200	7.681333	-.054
2A	285.6500	5.42007	5.41985	.004	7.678500	7.683527	-.065
2A	284.6500	5.30464	5.30441	.004	7.678900	7.687088	-.107
2A	283.6500	5.18952	5.18940	.002	7.679200	7.687745	-.111
2A	283.1500	5.13214	5.13210	.001	7.679400	7.684553	-.087
2A	282.6500	5.07498	5.07498	-.000	7.679600	7.678838	.010
2A	282.5000	5.05789	5.05789	-.000	7.679600	7.675203	.057
2A	282.3440	5.04020	5.04016	.001	7.679700	7.762056	-1.072
2A	303.1500	7.45336	7.45393	-.008	7.621770	7.620178	.021
2A	298.1500	6.86844	6.86851	-.001	7.623570	7.623313	.003
2A	293.1500	6.28553	6.28531	.003	7.625370	7.626623	-.046
2A	289.1500	5.82149	5.82117	.005	7.626800	7.629959	-.041
2A	285.6500	5.41783	5.41766	.003	7.628060	7.631947	-.051
2A	284.6500	5.30310	5.30300	.002	7.628420	7.632191	-.049
2A	283.6500	5.18875	5.18869	.001	7.628780	7.632857	-.053
2A	283.1500	5.13169	5.13171	-.000	7.628950	7.626546	.032
2A	282.6500	5.07481	5.07486	-.001	7.629130	7.606356	.299
2A	282.3440	5.04007	5.04016	-.002	7.629240	7.492949	1.786
2A	303.1500	7.43832	7.43893	-.008	7.582800	7.581088	.023
2A	298.1500	6.85752	6.85760	-.001	7.584500	7.584204	.004
2A	293.1500	6.27857	6.27834	.004	7.586300	7.587617	-.017
2A	289.1500	5.81749	5.81716	.006	7.587800	7.591089	-.043
2A	285.6500	5.41617	5.41598	.004	7.589000	7.593476	-.059
2A	284.6500	5.30198	5.30191	.001	7.589400	7.591987	-.034
2A	283.6500	5.18817	5.18815	.000	7.589700	7.591210	-.020
2A	283.1500	5.13139	5.13141	-.000	7.589900	7.587625	.030
2A	282.6500	5.07473	5.07477	-.001	7.590100	7.572202	.236
2A	282.3440	5.04016	5.04016	-.000	7.590200	7.534842	.729
2A	303.1500	7.40673	7.40710	-.005	7.499400	7.498349	.014
2A	298.1500	6.83445	6.83453	-.001	7.501200	7.500903	.004
2A	293.1500	6.26383	6.26359	.004	7.502900	7.504331	-.019
2A	289.1500	5.80890	5.80863	.005	7.504300	7.506977	-.036
2A	285.6500	5.41252	5.41240	.002	7.505600	7.508351	-.037
2A	284.6500	5.29966	5.29959	.001	7.505900	7.508313	-.032
2A	283.6500	5.18698	5.18699	-.000	7.506300	7.505527	.010
2A	283.1500	5.13070	5.13076	-.001	7.506500	7.498144	.111
2A	282.6500	5.07449	5.07457	-.002	7.506600	7.471538	.467
2A	282.3440	5.04011	5.04016	-.001	7.506700	7.392577	1.520
2A	298.1500	6.58548	6.58491	.009	6.579700	6.581888	-.033
2A	293.1500	6.10120	6.10096	.004	6.581300	6.582647	-.020
2A	289.1500	5.71173	5.71176	-.001	6.582500	6.582234	.004
2A	285.6500	5.36833	5.36860	-.005	6.583600	6.578960	.070
2A	283.6500	5.16997	5.17027	-.006	6.584200	6.573036	.170
2A	298.1500	6.38762	6.38666	.015	5.899000	5.902252	-.055
2A	282.3440	5.02541	5.02552	-.002	5.903300	5.900275	.051
2A	282.0393	4.99780	4.99799	-.004	5.903400	5.897413	.101

BEST DOCUMENT AVAILABLE

Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
2B	298.1500	8.39638	8.38978	.079	10.817200	10.824430	-.068
2B	280.0394	4.84374	4.84231	.029	10.626500	10.632286	-.054
2B	279.5394	4.75176	4.74989	.039	10.626800	10.635088	-.078
2B	279.3625	4.71942	4.71724	.046	10.626800	10.636740	-.094
2B	298.1500	7.23084	7.23176	-.011	8.750000	8.747744	.026
2B	282.3700	5.04648	5.04613	.007	8.756600	8.784006	-.313
2B	282.3440	5.04315	5.04280	.007	8.756600	8.784956	-.324
2B	282.2143	5.02663	5.02627	.007	8.756600	8.794163	-.429
2B	282.1893	5.02347	5.02309	.007	8.756700	8.797239	-.463
2B	303.1500	7.44551	7.44643	-.012	7.602300	7.599740	.034
2B	298.1500	6.86296	6.86308	-.002	7.604100	7.603709	.005
2B	293.1500	6.28229	6.28184	.007	7.605900	7.608538	-.035
2B	289.1500	5.81975	5.81916	.010	7.607300	7.613134	-.077
2B	285.6500	5.41734	5.41682	.010	7.608500	7.620581	-.160
2B	284.6500	5.30307	5.30245	.012	7.608900	7.631131	-.292
2B	283.6500	5.18886	5.18842	.008	7.609300	7.640665	-.412
2B	283.1500	5.13189	5.13156	.006	7.609400	7.652152	-.562
2B	282.6500	5.07514	5.07482	.006	7.609600	7.739052	-1.701
2B	282.5500	5.06378	5.06349	.006	7.609600	7.787493	-2.338
2B	282.4500	5.05243	5.05216	.005	7.609700	7.848875	-3.143
2B	282.3440	5.04045	5.04016	.006	7.609700	7.732198	-1.610
2B	298.1500	6.56656	6.56593	.010	6.511200	6.513592	-.037
2B	293.1500	6.08870	6.08818	.009	6.512800	6.515674	-.044
2B	289.1500	5.70401	5.70374	.005	6.514000	6.516311	-.035
2B	285.6500	5.36469	5.36453	.003	6.515000	6.517597	-.040
2B	283.6500	5.16848	5.16836	.002	6.515600	6.519788	-.064
2B	282.3440	5.03822	5.03807	.003	6.516000	6.534598	-.285
2B	298.1500	6.38612	6.38517	.015	5.894200	5.897429	-.055
2B	293.1500	5.96311	5.96213	.016	5.895500	5.900023	-.077
2B	289.1500	5.62133	5.62040	.017	5.896600	5.902760	-.104
2B	285.6500	5.31829	5.31759	.013	5.897600	5.905107	-.127
2B	283.6500	5.14244	5.14189	.011	5.898100	5.907298	-.156
2B	282.3410	5.02570	5.02534	.007	5.898500	5.908266	-.166
2B	282.2393	5.01624	5.01591	.007	5.898500	5.908148	-.164
2B	282.1393	5.00720	5.00688	.006	5.898600	5.908367	-.166
2B	281.9393	4.98901	4.98878	.005	5.898600	5.906675	-.137
2B	281.8393	4.97992	4.97970	.004	5.898600	5.906706	-.137
2B	281.7393	4.97071	4.97062	.002	5.898700	5.902345	-.062
1	282.3500	5.04197	5.04084	.022	7.635000	7.797934	-2.134
1	282.3600	5.04288	5.04198	.018	7.635000	7.800451	-2.167
1	282.3700	5.04403	5.04311	.018	7.635000	7.809395	-2.284
1	282.3800	5.04516	5.04424	.019	7.635000	7.818024	-2.397
1	282.3900	5.04628	5.04538	.018	7.635000	7.827379	-2.520
1	282.4000	5.04744	5.04651	.018	7.635000	7.836230	-2.636
1	282.4100	5.04858	5.04764	.019	7.635000	7.845222	-2.753
1	282.4200	5.04978	5.04878	.020	7.635000	7.854504	-2.875
1	282.4300	5.05083	5.04991	.018	7.635000	7.862467	-2.980
1	282.4500	5.05324	5.05218	.021	7.635000	7.878148	-3.185
1	282.5500	5.06452	5.06352	.020	7.635000	7.930706	-3.873

BEST DOCUMENT AVAILABLE

Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
1	282.6500	5.07586	5.07488	.019	7.635000	7.914154	-3.656
1	282.7500	5.08723	5.08624	.019	7.635000	7.873055	-3.118
1	282.8500	5.09858	5.09761	.019	7.635000	7.830066	-2.555
1	282.9500	5.10994	5.10898	.019	7.635000	7.795675	-2.104
1	283.0500	5.12136	5.12037	.019	7.635000	7.776276	-1.850
1	283.1500	5.13277	5.13176	.020	7.635000	7.759454	-1.630
1	283.3500	5.15587	5.15455	.022	7.635000	7.741249	-1.392
1	284.1500	5.24722	5.24593	.025	7.635000	7.696503	-.806
1	285.1500	5.36197	5.36053	.027	7.635000	7.675587	-.531
1	286.1500	5.47701	5.47548	.028	7.635000	7.664942	-.392
1	287.1500	5.59247	5.59074	.031	7.635000	7.660746	-.337
1	288.1500	5.70808	5.70626	.032	7.635000	7.656658	-.284
1	293.1500	6.28886	6.28704	.029	7.635000	7.645534	-.138
1	298.1500	6.87365	6.87171	.028	7.635000	7.642283	-.095
1	303.1500	7.46149	7.45904	.033	7.635000	7.641778	-.089
1	283.1500	5.10345	5.10241	.020	6.000000	6.023921	-.399
1	288.1500	5.54964	5.54816	.027	6.000000	6.011648	-.194
1	293.1500	5.98672	5.98515	.026	6.000000	6.007560	-.126
1	298.1500	6.42028	6.41773	.040	6.000000	6.008853	-.148
1	303.1500	6.84890	6.84738	.022	6.000000	6.004152	-.069
1	283.1500	5.11928	5.11846	.016	6.500000	6.539665	-.610
1	288.1500	5.60692	5.60572	.021	6.500000	6.512006	-.185
1	293.1500	6.08774	6.08577	.032	6.500000	6.510856	-.167
1	298.1500	6.56526	6.56281	.037	6.500000	6.509280	-.143
1	303.1500	7.03963	7.03798	.023	6.500000	6.504772	-.073
1	283.1500	5.12707	5.12625	.016	7.000000	7.080309	-1.147
1	288.1500	5.65366	5.65253	.020	7.000000	7.013259	-.189
1	293.1500	6.17782	6.17599	.030	7.000000	7.010858	-.155
1	298.1500	6.70124	6.69893	.034	7.000000	7.009055	-.129
1	303.1500	7.22319	7.22170	.021	7.000000	7.004380	-.063
1	283.1500	5.13169	5.13071	.019	7.500000	7.624604	-1.661
1	288.1500	5.69652	5.69483	.030	7.500000	7.520410	-.272
1	293.1500	6.26526	6.26308	.035	7.500000	7.512838	-.171
1	298.1500	6.83652	6.83420	.034	7.500000	7.508888	-.119
1	303.1500	7.40872	7.40733	.019	7.500000	7.503930	-.052
1	283.1500	5.13594	5.13481	.022	8.000000	8.103823	-1.298
1	288.1500	5.74068	5.73870	.038	8.000000	8.023506	-.294
1	293.1500	6.35743	6.35480	.041	8.000000	8.014007	-.175
1	298.1500	6.98029	6.97763	.038	8.000000	8.009298	-.116
1	303.1500	7.60625	7.60492	.017	8.000000	8.003442	-.043
1	283.1500	5.14271	5.14141	.025	8.500000	8.562742	-.738
1	288.1500	5.79342	5.79106	.041	8.500000	8.519981	-.235
1	293.1500	6.46250	6.46020	.036	8.500000	8.510251	-.121
1	298.1500	7.14174	7.13977	.028	8.500000	8.505906	-.069
1	303.1500	7.82674	7.82622	.007	8.500000	8.501175	-.014
1	283.1500	5.15732	5.15588	.028	9.000000	9.031780	-.353
1	288.1500	5.86313	5.86107	.035	9.000000	9.012601	-.140
1	293.1500	6.59227	6.59056	.026	9.000000	9.006005	-.067
1	298.1500	7.33468	7.33347	.017	9.000000	9.002977	-.033
1	303.1500	8.08490	8.08531	-.005	9.000000	8.999225	.009
1	283.1500	5.18994	5.18874	.023	9.500000	9.512497	-.132
1	288.1500	5.96313	5.96149	.028	9.500000	9.506879	-.072
1	293.1500	6.76196	6.76038	.023	9.500000	9.504175	-.044

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Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
1	298.1500	7.57508	7.57459	.007	9.500000	9.500959	-.010
1	303.1500	8.39804	8.39918	-.014	9.500000	9.498235	.019
1	283.1500	5.25792	5.25693	.019	10.000000	10.005284	-.053
1	288.1500	6.11098	6.10974	.020	10.000000	10.003532	-.035
1	293.1500	6.99048	6.98814	.033	10.000000	10.004588	-.046
1	298.1500	7.88281	7.88257	.003	10.000000	10.000366	-.004
1	303.1500	8.79026	8.78816	.024	10.000000	10.002596	-.026
1	283.1500	5.38690	5.38340	.065	10.500000	10.510550	-.100
1	288.1500	6.33296	6.32812	.076	10.500000	10.509354	-.089
1	293.1500	7.30284	7.29650	.087	10.500000	10.509159	-.087
1	298.1500	8.29048	8.28063	.119	10.500000	10.511444	-.109
1	303.1500	9.28873	9.27603	.137	10.500000	10.512411	-.118
1	280.1500	4.83757	4.83427	.068	10.500000	10.515588	-.148
1	280.1500	4.81814	4.81532	.059	10.400000	10.415616	-.150
1	280.1500	4.81214	4.80947	.055	10.365500	10.381149	-.151
1	280.1500	4.80596	4.80366	.048	10.329100	10.343470	-.139
1	280.1500	4.80263	4.80031	.048	10.307000	10.322035	-.146
1	280.1500	4.79995	4.79910	.018	9.900000	9.905268	-.053
1	280.1500	4.79989	4.79910	.016	8.250000	8.253402	-.041
1	280.1500	4.79970	4.79910	.013	6.800000	6.801760	-.026
1	280.1500	4.79960	4.79910	.010	5.800000	5.801068	-.018
1	281.1500	5.01853	5.01542	.062	10.500000	10.512315	-.117
1	281.1500	4.92924	4.92778	.030	10.000000	10.012537	-.125
1	281.1500	4.91885	4.91745	.029	9.899000	9.913674	-.148
1	281.1500	4.91325	4.91176	.030	9.833000	9.850774	-.181
1	281.1500	4.91168	4.91022	.030	9.813400	9.831534	-.185
1	281.1500	4.91022	4.90873	.030	9.793600	9.812843	-.196
1	281.1500	4.90938	4.90777	.033	9.780300	9.801638	-.218
1	281.1500	4.90885	4.90731	.031	9.773700	9.794532	-.213
1	281.1500	4.90837	4.90736	.021	9.767300	9.781115	-.141
1	281.1500	4.90826	4.90736	.018	9.300000	9.311185	-.120
1	281.1500	4.90822	4.90736	.018	8.100000	8.108141	-.101
1	281.1500	4.90804	4.90736	.014	6.200000	6.203784	-.061
1	281.1500	4.90601	4.90524	.016	5.500000	5.516828	-.306
1	281.6500	4.97260	4.97138	.025	9.592500	9.612074	-.204
1	281.6500	4.96918	4.96794	.025	9.530000	9.552098	-.240
1	281.6500	4.96762	4.96647	.023	9.500000	9.522903	-.241
1	281.6500	4.96606	4.96479	.026	9.462700	9.490067	-.289
1	281.6500	4.96472	4.96353	.024	9.432000	9.459807	-.295
1	281.6500	4.96393	4.96262	.026	9.408050	9.440300	-.343
1	281.6500	4.96300	4.96253	.009	5.900000	5.904845	-.082
1	281.6500	4.96067	4.95983	.017	5.800000	5.829248	-.504
1	281.6500	4.95740	4.95639	.020	5.700000	5.727739	-.487
1	281.6500	4.94814	4.94693	.024	5.500000	5.521962	-.399
1	282.1500	5.20165	5.19852	.060	10.500000	10.510703	-.102
1	282.1500	5.09211	5.09120	.018	10.000000	10.006037	-.060
1	282.1500	5.04078	5.03979	.020	9.500000	9.515163	-.160
1	282.1500	5.02694	5.02584	.022	9.200000	9.231517	-.343
1	282.1500	5.02425	5.02305	.024	9.100000	9.143214	-.475
1	282.1500	5.02198	5.02096	.020	9.000000	9.048220	-.536
1	282.1500	5.02061	5.01945	.023	8.900000	8.968825	-.773
1	282.1500	5.01990	5.01884	.021	8.845200	8.918681	-.833
1	282.1500	5.01959	5.01845	.023	8.802400	8.888712	-.981
1	282.1500	5.01951	5.01843	.022	8.800000	8.883761	-.952

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Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
1	282.1500	5.01843	5.01759	.017	6.400000	6.454023	-.844
1	282.1500	5.01741	5.01656	.017	6.300000	6.390674	-1.439
1	282.1500	5.01608	5.01515	.018	6.200000	6.265869	-1.062
1	282.1500	5.01181	5.01089	.018	6.000000	6.036959	-.616
1	282.1500	5.00892	5.00790	.020	5.900000	5.932741	-.555
1	282.1500	5.00530	5.00423	.021	5.800000	5.827858	-.490
1	282.1500	4.98973	4.98840	.027	5.500000	5.520626	-.375
1	282.2500	5.03540	5.03427	.022	9.000000	9.047636	-.529
1	282.2500	5.03228	5.03123	.021	8.900000	8.872435	-.823
1	282.2500	5.03142	5.03035	.021	8.700000	8.792945	-1.068
1	282.2500	5.03069	5.02978	.022	8.600000	8.716073	-1.350
1	282.2500	5.03035	5.02954	.016	6.750000	6.818949	-1.021
1	282.2500	5.02995	5.02904	.018	6.600000	6.701767	-1.542
1	282.2500	5.02939	5.02843	.019	6.500000	6.705221	-4.388
1	282.2500	5.02842	5.02755	.017	6.400000	6.515809	-1.810
1	282.2500	5.02116	5.02011	.021	6.000000	6.040185	-.670
1	282.2500	4.99803	4.99668	.027	5.500000	5.520597	-.374
1	282.3500	5.23803	5.23536	.051	10.500000	10.506902	-.065
1	282.3500	5.12506	5.12417	.017	10.000000	10.005617	-.056
1	282.3500	5.07067	5.06935	.026	9.500000	9.518329	-.193
1	282.3500	5.04902	5.04762	.028	9.000000	9.052224	-.580
1	282.3500	5.04295	5.04168	.026	8.500000	8.635545	-1.595
1	282.3500	5.04200	5.04087	.022	8.000000	8.176168	-2.202
1	282.3500	5.04200	5.04085	.023	7.750000	7.918312	-2.172
1	282.3500	5.04194	5.04084	.022	7.500000	7.656728	-2.090
1	282.3500	5.04188	5.04082	.021	7.250000	7.397917	-2.040
1	282.3500	5.04178	5.04067	.022	7.000000	7.158214	-2.260
1	282.3500	5.03966	5.03853	.022	6.500000	6.704560	-3.147
1	282.3500	5.03051	5.02931	.024	6.000000	6.042159	-.703
1	282.3500	5.00613	5.00491	.024	5.500000	5.517730	-.322
1	282.4000	5.04746	5.04651	.019	7.650000	7.851210	-2.630
1	282.4000	5.04741	5.04650	.018	7.600000	7.801216	-2.648
1	282.4500	5.05343	5.05247	.019	8.000000	8.202698	-2.534
1	282.4500	5.05322	5.05225	.019	7.750000	7.982894	-3.005
1	282.4500	5.05309	5.05219	.018	7.650000	7.893216	-3.179
1	282.4500	5.05309	5.05216	.018	7.600000	7.848177	-3.265
1	282.4500	5.05303	5.05209	.019	7.500000	7.762355	-3.502
1	282.4500	5.05283	5.05188	.019	7.250000	7.579103	-4.539
1	282.4500	5.05235	5.05146	.018	7.000000	7.925805	13.226
1	282.5500	5.06449	5.06354	.019	7.650000	7.938433	-3.770
1	282.5500	5.06446	5.06347	.019	7.600000	7.906237	-4.029
1	282.6500	5.08923	5.08795	.026	9.000000	9.039808	-.442
1	282.6500	5.07993	5.07874	.023	8.500000	8.593304	-1.098
1	282.6500	5.07695	5.07585	.022	8.000000	8.191538	-2.394
1	282.6500	5.07616	5.07515	.020	7.750000	7.997926	-3.198
1	282.6500	5.07590	5.07491	.019	7.650000	7.925024	-3.595
1	282.6500	5.07575	5.07479	.019	7.600000	7.886625	-3.771
1	282.6500	5.07556	5.07456	.020	7.500000	7.827609	-4.368
1	282.6500	5.07481	5.07389	.018	7.250000	7.625743	-5.183
1	282.6500	5.07383	5.07294	.018	7.000000	7.275154	-3.931
1	282.6500	5.07221	5.07136	.017	6.750000	6.882392	-1.961
1	282.6500	5.06950	5.06867	.016	6.500000	6.567970	-1.046

BEST DOCUMENT AVAILABLE

Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
1	282.6500	5.05791	5.05683	.021	6.000000	6.031517	-.525
1	282.8500	5.10045	5.09937	.021	8.000000	8.145839	-1.823
1	282.8500	5.09920	5.09812	.021	7.750000	7.941939	-2.477
1	282.8500	5.09867	5.09767	.020	7.650000	7.846700	-2.571
1	282.8500	5.09845	5.09746	.019	7.600000	7.803523	-2.678
1	282.8500	5.09804	5.09702	.020	7.500000	7.720402	-2.939
1	282.8500	5.09675	5.09584	.018	7.250000	7.447809	-2.728
1	282.8500	5.09507	5.09431	.015	7.000000	7.122422	-1.749
1	283.1500	5.13368	5.13268	.020	7.750000	7.867914	-1.521
1	283.1500	5.12950	5.12868	.016	7.250000	7.348742	-1.362
1	283.1500	5.12379	5.12302	.015	6.750000	6.804352	-.805
1	283.3500	5.18470	5.18327	.028	9.000000	9.028782	-.320
1	283.3500	5.16820	5.16669	.029	8.500000	8.561373	-.724
1	283.3500	5.15981	5.15853	.025	8.000000	8.094200	-1.178
1	283.3500	5.15692	5.15573	.023	7.750000	7.856452	-1.374
1	283.3500	5.15419	5.15318	.020	7.500000	7.598528	-1.314
1	283.3500	5.15144	5.15055	.017	7.250000	7.332835	-1.140
1	283.3500	5.14829	5.14749	.016	7.000000	7.061968	-.865
1	283.3500	5.14440	5.14357	.016	6.750000	6.798297	-.716
1	283.3500	5.13908	5.13827	.016	6.500000	6.533822	-.520
1	283.3500	5.12159	5.12056	.020	6.000000	6.021887	-.365
1	283.3500	5.08842	5.08697	.028	5.500000	5.516599	-.302
1	284.1500	5.57352	5.56985	.066	10.500000	10.509930	-.095
1	284.1500	5.42568	5.42462	.020	10.000000	10.004796	-.048
1	284.1500	5.34153	5.34013	.026	9.500000	9.511175	-.118
1	284.1500	5.29548	5.29375	.033	9.000000	9.025101	-.279
1	284.1500	5.27042	5.26868	.033	8.500000	8.544784	-.527
1	284.1500	5.25551	5.25395	.030	8.000000	8.062361	-.780
1	284.1500	5.24984	5.24834	.025	7.750000	7.809672	-.770
1	284.1500	5.24427	5.24314	.022	7.500000	7.554759	-.730
1	284.1500	5.23885	5.23789	.018	7.250000	7.294869	-.619
1	284.1500	5.23306	5.23214	.017	7.000000	7.038093	-.544
1	284.1500	5.22627	5.22541	.017	6.750000	6.779889	-.443
1	284.1500	5.21797	5.21709	.017	6.500000	6.524163	-.372
1	284.1500	5.19400	5.19278	.023	6.000000	6.020026	-.334
1	284.1500	5.15364	5.15210	.030	5.500000	5.515228	-.277
1	284.1500	5.67503	5.67387	.020	7.250000	7.264067	-.194
1	289.1500	5.63106	5.63007	.018	6.750000	6.760909	-.162
4	283.1700	5.10770	5.10684	.017	6.080000	6.081330	-.352
4	287.3700	5.48740	5.48630	.020	6.060000	6.069942	-.164
4	293.3400	6.01530	6.01471	.010	6.060000	6.062836	-.047
4	298.1900	6.43890	6.43815	.012	6.058000	6.058623	-.043
4	285.5400	5.42540	5.42420	.022	8.063000	8.087988	-.310
4	291.9000	6.21100	6.21070	.005	8.063000	8.064815	-.023
4	292.7500	6.31690	6.31702	-.002	8.063000	8.062361	.008
4	293.1500	7.20000	7.20188	-.026	10.362000	10.359027	.029
4	293.6900	7.30330	7.30472	-.019	10.362000	10.359812	.021
4	298.1400	7.99060	8.01997	-.368	10.190000	10.148722	.405
4	298.1400	6.99690	6.99828	-.020	8.072000	8.067244	.059
4	298.1400	6.69610	6.69977	-.055	7.007000	6.992544	.206
3	283.6500	5.14322	5.14226	.019	5.904244	5.920517	-.276
3	285.6500	5.31888	5.31822	.012	5.904244	5.911351	-.120
3	289.1500	5.62216	5.62158	.010	5.904244	5.908078	-.065
3	293.1500	5.96416	5.96409	.001	5.904244	5.904564	-.005
3	298.1500	6.38814	6.38829	-.002	5.904244	5.903725	.009
3	283.6500	5.16045	5.15947	.019	6.253953	6.279469	-.408
3	285.6500	5.34820	5.34725	.018	6.253953	6.267369	-.215
3	289.1500	5.67198	5.67135	.011	6.253953	6.258864	-.079

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Table II. (Continued)

EXPT ID	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	% DIFF	DENSITY (MOL/DM3) EXP	CALC	% DIFF
3	293.1500	6.03833	6.03800	.005	6.253953	6.255661	-.027
3	298.1500	6.49362	6.49302	.009	6.253953	6.256160	-.035
3	283.6500	5.16362	5.16330	.006	6.356947	6.366096	-.144
3	285.6500	5.35447	5.35445	.000	6.356947	6.357318	-.006
3	289.1500	5.68487	5.68458	.005	6.356947	6.359293	-.037
3	293.1500	6.05796	6.05836	-.007	6.356947	6.354826	.033
3	298.1500	6.52247	6.52256	-.001	6.356947	6.356629	.005
3	283.6500	5.17651	5.17573	.015	6.815134	6.853609	-.565
3	285.6500	5.38111	5.38114	-.001	6.815134	6.814490	.009
3	289.1500	5.73825	5.73773	.009	6.815134	6.820042	-.072
3	293.1500	6.14315	6.14339	-.004	6.815134	6.813733	.021
3	298.1500	6.64913	6.64915	-.000	6.815134	6.815047	.001
3	283.6500	5.17738	5.17672	.013	6.863326	6.897564	-.499
3	285.6500	5.38421	5.38356	.012	6.863326	6.876538	-.193
3	289.1500	5.74278	5.74291	-.002	6.863326	6.862075	.018
3	293.1500	6.15210	6.15195	.002	6.863326	6.864198	-.013
3	298.1500	6.66181	6.66217	-.005	6.863326	6.861933	.020
3	283.6500	5.18517	5.18383	.026	7.283886	7.377382	-1.284
3	285.6500	5.40368	5.40289	.015	7.283886	7.302369	-.254
3	289.1500	5.78719	5.78633	.015	7.283886	7.292606	-.120
3	293.1500	6.22585	6.22534	.008	7.283886	7.286930	-.042
3	298.1500	6.77549	6.77529	.003	7.283886	7.284672	-.011
3	283.6500	5.18830	5.18668	.031	7.484253	7.599153	-1.535
3	285.6500	5.41282	5.41149	.025	7.484253	7.515553	-.418
3	289.1500	5.80755	5.80660	.016	7.484253	7.493849	-.128
3	293.1500	6.26115	6.26031	.013	7.484253	7.489230	-.067
3	298.1500	6.82979	6.82986	-.001	7.484253	7.483969	.004
3	283.6500	5.19154	5.18995	.031	7.718022	7.824272	-1.377
3	285.6500	5.42238	5.42158	.015	7.718022	7.736258	-.236
3	289.1500	5.83135	5.83065	.012	7.718022	7.724856	-.089
3	293.1500	6.30224	6.30201	.004	7.718022	7.719340	-.017
3	298.1500	6.89369	6.89516	-.021	7.718022	7.712568	.071
3	283.6500	5.19785	5.19597	.036	8.101763	8.196670	-1.171
3	285.6500	5.44163	5.43957	.038	8.101763	8.141620	-.492
3	289.1500	5.87440	5.87290	.026	8.101763	8.114814	-.161
3	293.1500	6.37711	6.37482	.036	8.101763	8.113628	-.146
3	298.1500	7.00764	7.00873	-.016	8.101763	8.098042	.046
3	283.6500	5.21258	5.21157	.019	8.712710	8.739165	-.304
3	285.6500	5.47945	5.47805	.025	8.712710	8.730205	-.201
3	289.1500	5.95566	5.95555	.002	8.712710	8.713427	-.008
3	293.1500	6.51140	6.51185	-.007	8.712710	8.710873	.021
3	298.1500	7.21383	7.21747	-.051	8.712710	8.702549	.117
3	283.6500	5.21950	5.21694	.049	8.845913	8.899487	-.606
3	285.6500	5.49165	5.48927	.043	8.845913	8.872083	-.296
3	289.1500	5.97733	5.97759	-.004	8.845913	8.844349	.018
3	293.1500	6.54496	6.54693	-.030	8.845913	8.838375	.085
3	298.1500	7.26451	7.26953	-.069	8.845913	8.832640	.150
3	283.6500	5.24750	5.24722	.005	9.326219	9.329455	-.035
3	285.6500	5.54389	5.54371	.003	9.326219	9.327466	-.013
3	289.1500	6.07423	6.07534	-.018	9.326219	9.321444	.051
3	293.1500	6.69265	6.69582	-.047	9.326219	9.316844	.101
3	298.1500	7.47712	7.48426	-.096	9.326219	9.310961	.164
3	283.6500	5.28952	5.29032	-.015	9.708117	9.702464	.058
3	285.6500	5.61008	5.60953	.010	9.708117	9.710811	-.028
3	289.1500	6.17898	6.18074	-.028	9.708117	9.702399	.059
3	293.1500	6.84089	6.84694	-.088	9.708117	9.693777	.148
3	298.1500	7.68440	7.69341	-.117	9.708117	9.692157	.164
3	283.6500	5.50719	5.50804	-.015	10.586729	10.584484	.021
3	285.6500	5.89065	5.89055	.002	10.586729	10.586956	-.002
3	289.1500	6.56807	6.57052	-.037	10.586729	10.582517	.040
3	293.1500	7.35645	7.36010	-.050	10.586729	10.581675	.048
3	298.1500	8.35838	8.35077	-.029	10.586729	10.584057	.025

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Table III. Comparison of experimental saturation pressures and densities with the formulation

	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	PRESSURE DIFF MPA	%	DENSITY (MOL/DM3) EXP	CALC	DENSITY DIFF MOL/DM3	%
1	279.1500	4.69367	4.69325	-.00042	-.009	4.72460	4.70643	-.01817	-.385
1	279.1500	4.69367	4.69325	-.00042	-.009	10.67400	10.69686	.02286	.214
1	280.1500	4.79973	4.79910	-.00063	-.013	5.07100	5.06431	-.00669	-.132
1	280.1500	4.79973	4.79910	-.00063	-.013	10.28000	10.29877	.00877	.085
1	281.1500	4.90813	4.90736	-.00077	-.016	5.54600	5.54746	.00146	.026
1	281.1500	4.90813	4.90736	-.00077	-.016	9.76700	9.77447	.00747	.076
1	281.6500	4.96331	4.96246	-.00085	-.017	5.91100	5.89695	-.01405	-.238
1	281.6500	4.96331	4.96246	-.00085	-.017	9.38700	9.40369	.01669	.178
1	282.1500	5.01915	5.01828	-.00087	-.017	6.48900	6.49716	.00816	.126
1	282.1500	5.01915	5.01828	-.00087	-.017	8.78000	8.78099	.00099	.011
1	282.2000	5.02481	5.02391	-.00090	-.018				
1	282.2500	5.03048	5.02954	-.00092	-.018				
1	282.3000	5.03612	5.03519	-.00093	-.019				
2A	279.5230					10.55200	10.55789	.00589	.056
2A	280.6970					10.03200	10.03520	.00320	.032
2A	281.7810					9.29270	9.28025	-.01245	-.134
2A	282.0840					8.91730	8.89946	-.01784	-.200
2A	282.1650					8.76440	8.75055	-.01385	-.158
2B	279.3170					10.62700	10.63582	.00882	.083
2B	282.1650					8.75670	8.75055	-.00615	-.070
2A	281.6300					9.90350	9.42123	-.02322	-.393
2B	281.6600					5.89870	9.39481	.00671	.114
2A	279.4394	4.72372	4.72364	-.00008	-.002				
2A	280.6394	4.85179	4.85177	-.00002	-.000				
2A	280.5894	4.84640	4.84636	-.00004	-.001				
2A	280.5844	4.84596	4.84582	-.00014	-.003				
2A	281.7393	4.97268	4.97237	-.00031	-.006				
2A	281.6893	4.96707	4.96682	-.00025	-.005				
2A	282.0733	5.00997	5.00967	-.00030	-.006				
2A	282.0693	5.00948	5.00922	-.00026	-.005				
2A	282.0493	5.00729	5.00697	-.00032	-.006				

Table III. (continued)

	TEMPERATURE K	PRESSURE (MPA) EXP	CALC	PRESSURE DIFF MPA	%
2A	282.1632	5.02002	5.01976	-.00026	-.005
2A	282.1380	5.01718	5.01693	-.00025	-.005
2A	282.0500	5.00720	5.00705	-.00015	-.003
2A	281.7500	4.97375	4.97356	-.00019	-.004
2A	281.4500	4.94055	4.94034	-.00021	-.004
2A	281.1500	4.90746	4.90736	-.00010	-.002
2A	279.1500	4.69323	4.69325	.00002	.000
2A	281.7500	4.97366	4.97356	-.00010	-.002
2A	281.6893	4.96655	4.96682	.00027	.005
2A	281.4393	4.93896	4.93916	.00020	.004
2A	281.1393	4.90608	4.90619	.00011	.002
2A	280.6394	4.85177	4.85177	.00000	.000
2A	281.4393	4.93780	4.93916	.00136	.027
2A	280.6394	4.85132	4.85177	.00045	.009
2A	279.4394	4.72339	4.72364	.00025	.005
2B	279.2594	4.70489	4.70472	-.00017	-.004
2B	279.1394	4.69226	4.69214	-.00012	-.003
2B	282.1393	5.01753	5.01708	-.00045	-.009
2B	282.0893	5.01192	5.01146	-.00046	-.009
2B	282.0393	5.00628	5.00585	-.00043	-.009
2B	282.2500	5.02967	5.02954	-.00013	-.003
2B	282.1500	5.01841	5.01828	-.00013	-.003
2B	282.0500	5.00721	5.00705	-.00016	-.003
2B	281.7500	4.97372	4.97356	-.00016	-.003
2B	281.4500	4.94046	4.94034	-.00012	-.002
2B	281.1500	4.90747	4.90736	-.00011	-.002
2B	282.1893	5.02242	5.02270	.00028	.006
2B	282.1393	5.01690	5.01708	.00018	.004
2B	282.0893	5.01135	5.01146	.00011	.002
2B	282.0393	5.00573	5.00585	.00012	.002
2B	281.7393	4.97239	4.97237	-.00002	-.000
2B	281.6893	4.96693	4.96682	-.00011	-.002
2B	281.4393	4.93930	4.93916	-.00014	-.003
2B	281.4393	4.93873	4.93916	.00043	.009
2B	281.1393	4.90599	4.90819	.00020	.004

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Table IV. Comparison of the experimental speed of sound with the formulation.

DENS	T.K	W.EXP	W.CAL	DELTA W	% DIFF
5.50000	298.150	241.91000	242.96637	-1.05637	-.4367
5.54900	293.150	232.93200	233.20910	-.27710	-.1190
5.58000	288.150	222.62800	222.53074	.09726	.0437
5.60300	284.150	212.16600	212.61726	-.45126	-.2127
5.61300	282.350	205.51200	207.56345	-2.05145	-.9982
5.61600	281.650	201.86200	206.26015	-4.39815	-2.1768
6.00000	298.150	241.57300	242.43162	-.85862	-.3554
6.05700	293.150	231.57400	231.73117	-.15717	-.0679
6.08900	288.150	219.51300	219.41685	.09615	.0438
6.12500	284.150	205.84400	206.82650	-.78250	-.3801
6.13600	282.350	194.09100	198.22676	-4.13576	-2.1308
6.50000	298.150	242.77200	243.43902	-.66702	-.2748
6.57000	293.150	231.74000	231.73573	.00427	.0018
6.61900	288.150	217.77400	217.53422	.23978	.1101
6.64800	284.150	200.18300	200.81873	-.63573	-.3176
6.66000	282.350	174.98900	183.61327	-8.62427	-4.9285
7.00000	298.150	245.75100	246.27168	-.52068	-.2119
7.08200	293.150	233.76300	233.61840	.14460	.0619
7.13900	288.150	217.89400	217.48606	.40794	.1872
7.17100	284.150	196.29800	196.59387	-.29587	-.1507
7.50000	298.150	250.88600	251.28200	-.39600	-.1578
7.59400	293.150	238.05900	237.85640	.19260	.0809
7.65900	288.150	220.57500	220.05862	.51638	.2341
7.69500	284.150	196.03000	195.83742	.19258	.0982
8.00000	298.150	258.50200	258.86428	-.36228	-.1401
8.10400	293.150	245.18700	244.99916	.18784	.0766
8.17900	288.150	226.69700	226.11204	.58496	.2580
8.21900	284.150	200.80600	200.24903	.64697	.3220
8.23300	282.350	172.35400	159.84390	12.51010	7.2584
8.50000	298.150	269.04300	269.40842	-.36542	-.1358
8.61100	293.150	255.62100	255.48741	.13359	.0523
8.69800	288.150	236.91800	236.41878	.49922	.2107
8.74200	284.150	211.68200	210.04564	.73636	.3479
8.75700	282.350	185.53700	185.19053	.34647	.1867
9.00000	298.150	282.85400	283.23791	-.38391	-.1357
9.11100	293.150	269.78860	269.55179	.23681	.0876
9.21400	288.150	251.93500	251.43107	.50393	.2000
9.26300	284.150	228.79300	228.09131	.70169	.3067
9.28100	282.350	210.08600	210.31108	-.22508	-.1071
9.50000	298.150	300.68200	300.54494	.13706	.0456
9.60300	293.150	287.87500	287.18976	.68524	.2380
9.72500	288.150	271.63600	271.10114	.73486	.2703
9.78300	284.150	251.84500	250.98933	.85567	.3398
9.80200	282.350	238.19300	237.89592	.29708	.1247
9.80900	281.650	231.04700	232.02923	-.98223	-.4251
9.81400	281.150	224.90100	229.76267	-4.86167	-2.1617
10.00000	298.150	322.34300	321.34499	.99801	.3096
10.08800	293.150	309.81800	308.21270	1.60530	.5181
10.22700	288.150	296.38200	294.77895	1.60305	.5409
10.29800	284.150	279.92400	278.32151	1.60249	.5725
10.32100	282.350	269.66100	268.41720	1.24380	.4612
10.32900	281.650	264.93800	264.00546	.93254	.3520
10.33400	281.150	261.15200	260.84041	.31159	.1193
10.34400	280.150	252.47700	255.96340	-3.48640	-1.3809

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APPENDIX C

Tables of Thermodynamic Properties

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Table V. The Thermodynamic Properties of Ethylene as Functions of temperature along isochores.

5.75 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	21626.9	22387.7	164.368	160.39		
277.0	4.47336	.0000	.0996	21788.3	22568.2	165.551	162.32		
278.0	4.57436	.0000	.1018	21951.8	22747.3	166.141	164.92		
279.0	4.67757	.0000	.1041	22118.4	22931.9	166.739	166.59		
280.0	4.78307	.0000	.1065	22288.6	23121.4	167.351	174.20		
280.5	4.83671	.0000	.1078	22377.7	23218.9	167.668	178.37		
281.0	4.89096	.0000	.1091	22468.3	23318.9	167.988	184.30		
281.5	4.94498	.0317	.0881	22557.2	23417.2	168.305	57.05	2151.53	206.0
282.0	4.98898	.0413	.0877	22586.2	23453.8	168.407	57.88	1646.17	204.5
282.5	5.03266	.0508	.0871	22614.9	23490.1	168.509	56.91	1331.24	203.9
283.0	5.07605	.0599	.0868	22643.1	23525.9	168.609	55.92	1123.69	207.4
283.5	5.11920	.0688	.0862	22670.8	23561.1	168.707	55.05	975.94	209.0
284.0	5.16215	.0776	.0858	22698.2	23595.9	168.803	54.20	864.95	210.5
284.5	5.20491	.0862	.0855	22725.1	23630.3	168.898	53.60	778.27	212.0
285.0	5.24752	.0948	.0852	22751.8	23664.4	168.992	53.00	708.57	213.4
286.0	5.33232	.1114	.0848	22804.2	23731.6	169.175	51.98	603.20	216.1
287.0	5.41667	.1280	.0845	22855.8	23797.8	169.356	51.15	527.17	218.8
288.0	5.50064	.1444	.0842	22906.6	23863.2	169.532	50.45	469.63	221.0
289.0	5.58428	.1608	.0839	22956.7	23927.9	169.706	49.86	424.53	223.4
290.0	5.66764	.1769	.0838	23006.3	23992.0	169.877	49.34	388.23	225.7
291.0	5.75075	.1928	.0836	23055.4	24055.6	170.046	48.89	358.37	227.9
292.0	5.83363	.2089	.0835	23104.1	24118.7	170.213	48.49	333.38	230.0
293.0	5.91631	.2247	.0833	23152.4	24181.4	170.378	48.14	312.16	232.2
294.0	5.99880	.2405	.0832	23200.4	24243.7	170.542	47.82	293.92	234.2
296.0	6.16330	.2719	.0831	23296.5	24367.4	170.864	47.27	264.17	238.3
298.0	6.32721	.3030	.0830	23389.6	24490.0	171.181	46.81	240.96	242.2
300.0	6.49060	.3338	.0829	23482.8	24611.6	171.493	46.42	222.36	246.1

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Table V. (Continued)

6.00 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	21453.1	22192.2	164.260	156.11		
277.0	4.47336	.0000	.0996	21620.1	22365.7	164.827	157.96		
278.0	4.57436	.0000	.1018	21779.3	22541.7	165.401	160.46		
279.0	4.67757	.0000	.1041	21941.4	22721.0	165.983	163.98		
280.0	4.78307	.0000	.1065	22107.8	22905.0	166.578	169.37		
280.5	4.83671	.0000	.1078	22193.5	22999.6	166.884	173.36		
281.0	4.89096	.0000	.1091	22281.5	23096.6	167.197	179.05		
281.5	4.94586	.0000	.1104	22373.1	23197.4	167.523	188.22		
282.0	4.99703	.0240	.0925	22438.3	23271.1	167.755	60.98	2863.81	200.1
282.5	5.04309	.0333	.0917	22468.5	23309.0	167.862	59.64	2038.61	201.6
283.0	5.08876	.0423	.0911	22497.9	23346.0	167.966	58.13	1597.63	203.7
283.5	5.13414	.0509	.0908	22526.6	23382.3	168.067	56.88	1320.62	205.7
284.0	5.17928	.0594	.0902	22554.8	23418.0	168.166	55.84	1129.17	207.5
284.5	5.22422	.0678	.0898	22582.5	23453.2	168.264	54.96	988.40	209.3
285.0	5.26898	.0761	.0895	22609.8	23488.0	168.360	54.20	880.32	210.9
286.0	5.35808	.0926	.0891	22663.3	23556.4	168.547	52.94	724.94	214.0
287.0	5.44671	.1090	.0887	22715.8	23623.6	168.730	51.95	618.46	216.9
288.0	5.53495	.1253	.0885	22767.3	23689.8	168.909	51.13	540.87	219.5
289.0	5.62287	.1416	.0882	22818.1	23755.2	169.085	50.45	481.81	222.1
290.0	5.71052	.1577	.0881	22868.2	23820.0	169.259	49.86	435.36	224.6
291.0	5.79792	.1739	.0879	22917.8	23884.1	169.429	49.35	397.88	226.9
292.0	5.88511	.1900	.0878	22966.9	23947.8	169.598	48.91	367.01	229.2
293.0	5.97211	.2060	.0877	23015.7	24011.0	169.764	48.52	341.15	231.5
294.0	6.05894	.2221	.0876	23064.0	24073.8	169.929	48.17	319.18	233.7
296.0	6.23214	.2540	.0875	23159.7	24196.4	170.254	47.57	283.88	238.0
298.0	6.40480	.2857	.0874	23254.4	24321.8	170.572	47.08	256.79	242.1
300.0	6.57700	.3172	.0874	23348.1	24444.3	170.886	46.68	235.38	246.2

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Table V. (Continued)

6.25 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	21312.4	22012.3	163.608	152.17		
277.0	4.47336	.0000	.0996	21465.4	22181.2	164.161	153.96		
278.0	4.57436	.0000	.1018	21620.5	22352.4	164.720	156.36		
279.0	4.67757	.0000	.1041	21778.5	22526.9	165.287	159.74		
280.0	4.78307	.0000	.1065	21940.6	22705.9	165.867	164.92		
280.5	4.83671	.0000	.1078	22024.0	22797.9	166.165	168.76		
281.0	4.89096	.0000	.1091	22109.6	22892.2	166.470	174.22		
281.5	4.94586	.0000	.1104	22198.7	22990.1	166.787	183.02		
282.0	5.00133	.0114	.0972	22293.2	23093.5	167.122	62.90	6037.22	197.5
282.5	5.04972	.0204	.0962	22325.2	23133.1	167.235	62.95	3342.87	196.5
283.0	5.09759	.0289	.0954	22356.0	23171.7	167.344	60.59	2337.17	199.6
283.5	5.14511	.0371	.0948	22385.9	23209.1	167.450	58.80	1808.44	202.2
284.0	5.19236	.0453	.0944	22414.9	23245.7	167.552	57.41	1479.18	204.5
284.5	5.23940	.0534	.0940	22443.3	23281.6	167.652	56.28	1253.57	206.6
285.0	5.28626	.0614	.0937	22471.2	23317.0	167.750	55.33	1089.04	208.6
286.0	5.37955	.0776	.0933	22525.8	23386.5	167.941	53.83	864.93	212.1
287.0	5.47239	.0937	.0930	22579.0	23454.6	168.127	52.66	719.39	215.3
288.0	5.56486	.1098	.0927	22631.2	23521.5	168.308	51.73	617.32	218.3
289.0	5.65703	.1260	.0925	22682.5	23587.6	168.486	50.96	541.85	221.1
290.0	5.74895	.1422	.0923	22733.1	23653.0	168.661	50.30	483.82	223.8
291.0	5.84065	.1584	.0922	22783.1	23717.6	168.833	49.75	437.86	226.3
292.0	5.93217	.1746	.0921	22832.6	23781.8	169.003	49.26	400.59	228.8
293.0	6.02352	.1908	.0920	22881.7	23845.4	169.171	48.84	369.76	231.2
294.0	6.11472	.2070	.0920	22930.3	23908.7	169.336	48.46	343.87	233.5
296.0	6.29672	.2394	.0919	23026.6	24034.1	169.663	47.82	302.83	238.0
298.0	6.47827	.2718	.0919	23121.7	24158.2	169.983	47.29	271.80	242.4
300.0	6.65943	.3040	.0919	23215.8	24281.3	170.298	46.86	247.56	246.6

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Table V. (Continued)

6.50 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP J/(MOL.K)	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	21173.3	21846.3	163.006	148.53		
277.0	4.47336	.0000	.0996	21322.7	22010.9	163.546	150.28		
278.0	4.57436	.0000	.1018	21474.0	22177.8	164.092	152.57		
279.0	4.67757	.0000	.1041	21628.1	22347.7	164.645	155.83		
280.0	4.78307	.0000	.1065	21786.2	22522.1	165.211	160.81		
280.5	4.83671	.0000	.1078	21867.5	22611.6	165.501	164.51		
281.0	4.89096	.0000	.1091	21951.0	22703.5	165.798	169.76		
281.5	4.94586	.0000	.1104	22037.8	22798.7	166.107	178.23		
282.0	5.00145	.0000	.1119	22130.8	22900.2	166.437	196.86		
282.5	5.05363	.0115	.1004	22185.4	22962.8	166.630	67.01	5917.72	190.5
283.0	5.10357	.0194	.0995	22217.8	23003.0	166.745	63.19	3475.34	195.1
283.5	5.15310	.0271	.0988	22248.8	23041.6	166.854	60.70	2472.32	198.7
284.0	5.20236	.0348	.0984	22278.8	23079.0	166.960	58.89	1920.22	201.8
284.5	5.25140	.0425	.0981	22307.7	23115.6	167.062	57.49	1570.07	204.1
285.0	5.30028	.0502	.0978	22336.2	23151.6	167.162	56.35	1328.21	206.4
286.0	5.39765	.0659	.0974	22391.6	23222.0	167.356	54.59	1016.24	210.5
287.0	5.49460	.0817	.0971	22445.5	23290.8	167.544	53.26	824.14	214.1
288.0	5.59125	.0977	.0969	22498.2	23358.4	167.727	52.22	694.32	217.4
289.0	5.68764	.1138	.0967	22550.0	23425.0	167.907	51.37	600.91	220.4
290.0	5.78383	.1300	.0966	22601.0	23490.8	168.083	50.65	530.60	223.3
291.0	5.87983	.1463	.0966	22651.3	23555.9	168.256	50.05	475.86	226.1
292.0	5.97569	.1626	.0965	22701.1	23620.5	168.427	49.53	432.07	228.7
293.0	6.07142	.1790	.0964	22750.4	23684.5	168.596	49.08	396.29	231.3
294.0	6.16703	.1955	.0964	22799.3	23748.1	168.762	48.69	366.53	233.7
296.0	6.35796	.2284	.0964	22895.9	23874.1	169.090	48.00	319.94	238.5
298.0	6.54853	.2614	.0964	22991.4	23998.8	169.411	47.45	285.19	243.1
300.0	6.73881	.2943	.0965	23085.8	24122.6	169.727	47.00	258.33	247.5

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Table V. (Continued)

6.75 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP J/(MOL.K)	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	21044.5	21682.6	162.449	145.17		
277.0	4.47336	.0000	.0998	21130.5	21853.2	162.977	146.83		
278.0	4.57436	.0000	.1018	21338.4	22016.0	163.510	149.07		
279.0	4.67757	.0000	.1041	21488.9	22181.9	164.051	152.21		
280.0	4.78307	.0000	.1065	21643.3	22351.9	164.603	157.01		
280.5	4.83671	.0000	.1078	21722.7	22439.2	164.886	160.57		
281.0	4.89096	.0000	.1091	21804.1	22528.7	165.176	165.63		
281.5	4.94586	.0000	.1104	21888.8	22621.5	165.477	173.79		
282.0	5.00145	.0000	.1119	21979.4	22720.4	165.799	191.73		
282.5	5.05576	.0060	.1043	22049.4	22798.4	166.047	71.85	11280.83	183.4
283.0	5.10757	.0130	.1032	22083.6	22840.3	166.188	65.73	5132.44	190.6
283.5	5.15696	.0201	.1026	22115.6	22879.9	166.281	62.41	3308.23	195.2
284.0	5.21010	.0273	.1022	22146.2	22918.1	166.389	60.16	2430.40	198.9
284.5	5.26105	.0346	.1019	22175.8	22955.3	166.493	58.49	1915.78	201.9
285.0	5.31188	.0421	.1017	22204.8	22991.7	166.595	57.17	1578.62	204.6
286.0	5.41319	.0574	.1014	22260.9	23062.8	166.791	55.17	1165.53	209.2
287.0	5.51420	.0730	.1012	22315.3	23132.2	166.981	53.71	923.44	213.2
288.0	5.61497	.0888	.1011	22368.4	23200.2	167.168	52.57	765.16	216.8
289.0	5.71556	.1049	.1010	22420.5	23267.2	167.346	51.66	654.00	220.1
290.0	5.81601	.1212	.1009	22471.8	23333.4	167.524	50.90	571.88	223.3
291.0	5.91634	.1376	.1009	22522.3	23398.8	167.698	50.26	508.67	226.2
292.0	6.01657	.1541	.1009	22572.3	23463.6	167.869	49.71	459.08	229.0
293.0	6.11672	.1707	.1009	22621.8	23527.9	168.039	49.23	418.80	231.8
294.0	6.21679	.1874	.1009	22670.8	23591.8	168.205	48.82	385.58	234.4
296.0	6.41676	.2210	.1010	22767.7	23718.3	168.534	48.12	334.09	239.4
298.0	6.61653	.2548	.1011	22863.4	23843.6	168.858	47.58	298.13	244.3
300.0	6.81612	.2884	.1012	22958.0	23967.8	169.172	47.09	267.08	248.9

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Table V. (Continued)

7.00 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DED.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.27488	.0000	.0974	20924.9	21549.8	161.532	142.04		
277.0	4.47336	.0000	.0995	21067.7	21706.8	162.448	143.65		
278.0	4.67438	.0000	.1018	21212.4	21865.9	163.370	145.81		
279.0	4.87757	.0000	.1041	21359.6	22027.8	164.299	148.05		
280.0	5.08307	.0000	.1066	21510.6	22193.9	165.239	153.43		
280.5	5.18671	.0000	.1078	21588.1	22278.1	165.715	156.92		
281.0	5.29095	.0000	.1091	21667.7	22366.5	166.200	161.80		
281.5	5.39585	.0000	.1104	21750.4	22457.0	166.693	169.67		
282.0	5.50145	.0000	.1119	21836.8	22553.3	167.207	186.07		
282.5	5.60883	.0030	.1075	21917.9	22640.3	167.697	77.24	22327.92	175.7
283.0	5.71029	.0081	.1065	21953.7	22683.8	167.914	67.90	7259.57	186.3
283.5	5.81339	.0158	.1061	21988.5	22724.2	168.129	63.74	4224.66	192.2
284.0	5.91630	.0224	.1058	22017.7	22762.9	168.339	61.10	2943.00	196.6
284.5	6.01900	.0294	.1056	22047.8	22800.5	168.545	59.20	2243.63	200.1
285.0	6.12176	.0367	.1055	22077.0	22837.2	168.748	57.73	1806.37	203.2
285.5	6.42694	.0516	.1053	22133.5	22908.8	169.148	55.55	1293.64	208.3
287.0	6.53193	.0671	.1052	22188.3	22979.5	169.537	53.98	1005.28	212.8
288.0	6.63681	.0828	.1052	22241.6	23048.9	169.922	52.77	821.85	216.7
289.0	6.74160	.0991	.1052	22293.9	23114.1	170.304	51.81	695.52	220.3
290.0	6.84633	.1159	.1053	22345.3	23180.5	170.681	51.02	603.57	223.7
291.0	6.95101	.1331	.1053	22396.0	23246.1	171.156	50.36	533.82	226.8
292.0	7.05567	.1489	.1054	22446.1	23311.2	171.427	49.80	478.22	229.9
293.0	7.16030	.1658	.1054	22495.6	23376.6	171.797	49.31	435.39	232.7
294.0	7.26491	.1829	.1055	22544.7	23439.7	172.164	48.88	399.48	235.5
295.0	7.47410	.2172	.1056	22641.7	23568.6	172.888	48.17	344.25	240.8
296.0	7.68325	.2517	.1058	22737.5	23688.2	173.598	47.59	303.88	245.9
300.0	8.49237	.3964	.1060	22833.2	23816.8	174.632	47.12	273.15	250.8

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Table V. (Continued)

7.25 MOLE/LM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DED.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP J/(MOL.K)	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20813.5	21416.9	161.450	139.13		
277.0	4.47338	.0000	.0996	20853.4	21570.4	161.956	140.69		
278.0	4.57438	.0000	.1018	21095.1	21728.0	162.467	142.78		
279.0	4.67757	.0000	.1041	21239.2	21889.4	162.985	145.72		
280.0	4.78307	.0000	.1065	21387.0	22046.8	163.513	150.20		
280.5	4.83671	.0000	.1078	21462.9	22130.0	163.784	153.52		
281.0	4.89096	.0000	.1091	21540.8	22215.4	164.061	158.23		
281.5	4.94586	.0000	.1104	21621.6	22303.8	164.349	165.83		
282.0	5.00145	.0000	.1119	21708.0	22397.8	164.655	182.54		
282.5	5.05739	.0016	.1102	21791.3	22488.8	164.950	81.99	41304.58	168.6
283.0	5.11227	.0069	.1086	21878.4	22583.5	165.062	64.33	9386.98	182.9
283.5	5.16694	.0130	.1083	21961.7	22674.4	165.199	64.52	5007.65	189.9
284.0	5.22153	.0195	.1082	22049.2	22613.4	165.310	61.60	3344.80	194.9
284.5	5.27606	.0264	.1082	21923.4	22661.2	165.417	59.54	2486.17	199.9
285.0	5.33057	.0335	.1082	21952.8	22668.1	165.520	57.97	1967.74	202.3
286.0	5.43955	.0484	.1082	22009.6	22759.8	165.719	55.68	1378.90	208.1
287.0	5.54853	.0640	.1093	22064.4	22829.7	165.910	54.05	1057.36	212.9
288.0	5.65752	.0800	.1094	22117.8	22898.1	166.095	52.81	856.67	217.2
289.0	5.76654	.0964	.1095	22170.1	22965.5	166.277	51.83	720.28	221.1
290.0	5.87561	.1131	.1098	22221.5	23031.9	166.455	51.02	622.01	224.7
291.0	5.98472	.1300	.1098	22272.2	23097.7	166.629	50.35	548.03	228.0
292.0	6.09387	.1472	.1099	22322.3	23162.8	166.801	49.78	490.48	231.2
293.0	6.20307	.1645	.1100	22371.8	23227.4	166.970	49.29	444.51	234.3
294.0	6.31232	.1820	.1102	22420.9	23291.5	167.137	48.86	407.01	237.2
296.0	6.53084	.2172	.1104	22517.8	23418.6	167.468	48.14	349.62	242.8
298.0	6.74972	.2528	.1107	22613.5	23544.5	167.788	47.57	307.68	248.1
300.0	6.96895	.2888	.1109	22708.2	23669.4	168.105	47.11	276.24	253.2

Table V. (Continued)

7.50 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20709.6	21292.9	161.001	136.41		
277.0	4.47336	.0000	.0996	20846.7	21443.2	161.497	137.93		
278.0	4.57436	.0000	.1018	20985.6	21595.5	161.997	139.95		
279.0	4.67757	.0000	.1041	21126.9	21750.6	162.505	142.79		
280.0	4.78307	.0000	.1065	21271.7	21909.4	163.023	147.13		
280.5	4.83671	.0000	.1078	21346.0	21990.9	163.288	150.34		
281.0	4.89096	.0000	.1091	21422.3	22074.4	163.560	154.90		
281.5	4.94586	.0000	.1104	21501.4	22160.8	163.841	162.25		
282.0	5.00145	.0000	.1119	21595.8	22252.7	164.141	178.40		
282.5	5.05771	.0011	.1124	21670.0	22344.4	164.439	84.42	59634.62	163.8
283.0	5.11387	.0060	.1124	21707.6	22389.4	164.572	69.74	10589.86	180.8
283.5	5.17004	.0120	.1125	21741.0	22430.4	164.690	64.63	5377.12	188.7
284.0	5.22626	.0184	.1126	21772.5	22469.4	164.801	61.60	3512.63	194.2
284.5	5.28254	.0253	.1127	21802.8	22507.1	164.907	59.48	2577.92	198.6
285.0	5.33886	.0325	.1129	21832.1	22544.0	165.010	57.88	2023.64	202.3
286.0	5.45167	.0477	.1131	21888.8	22615.7	165.209	55.56	1404.07	208.5
287.0	5.56466	.0635	.1134	21943.5	22685.4	165.400	53.92	1070.56	213.7
288.0	5.67784	.0799	.1137	21996.7	22753.8	165.585	52.68	864.24	218.3
289.0	5.79118	.0967	.1139	22048.9	22821.1	165.766	51.70	724.90	222.4
290.0	5.90468	.1139	.1141	22100.2	22887.5	165.943	50.90	624.90	226.3
291.0	6.01832	.1313	.1143	22150.8	22953.2	166.117	50.23	549.89	229.8
292.0	6.13209	.1490	.1146	22200.7	23018.3	166.288	49.67	491.68	233.2
293.0	6.24598	.1668	.1148	22250.1	23082.9	166.457	49.18	445.28	236.4
294.0	6.36000	.1849	.1150	22299.1	23147.1	166.624	48.76	407.48	239.5
296.0	6.58833	.2213	.1153	22395.9	23274.3	166.952	48.06	349.75	245.4
298.0	6.81703	.2581	.1157	22491.4	23400.3	167.274	47.50	307.85	250.9
300.0	7.04608	.2951	.1161	22585.9	23525.4	167.590	47.04	276.14	256.1

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Table V. (Continued)

7.75 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20612.4	21176.8	160.581	133.87		
277.0	4.47336	.0000	.0996	20746.9	21324.2	161.067	135.34		
278.0	4.57436	.0000	.1018	20883.2	21473.5	161.558	137.30		
279.0	4.67757	.0000	.1041	21021.8	21625.4	162.056	140.06		
280.0	4.78307	.0000	.1065	21163.8	21781.0	162.564	144.26		
280.5	4.83671	.0000	.1078	21236.7	21860.8	162.824	147.37		
281.0	4.89096	.0000	.1091	21311.4	21942.5	163.090	151.79		
281.5	4.94586	.0000	.1104	21388.9	22027.1	163.366	158.90		
282.0	5.00145	.0000	.1119	21471.6	2211[illegible]9	163.659	174.53		
282.5	5.05797	.0011	.1144	21554.0	22206.6	163.951	83.40	56864.26	162.3
283.0	5.11537	.0062	.1152	21591.2	22251.2	164.083	69.04	10124.81	180.3
283.5	5.17306	.0123	.1157	21624.3	22291.8	164.200	64.04	5161.35	188.6
284.0	5.23094	.0191	.1160	21655.6	22330.5	164.310	61.08	3382.39	194.5
284.5	5.28899	.0262	.1164	21685.6	22368.0	164.415	59.02	2488.76	199.2
285.0	5.34717	.0337	.1167	21714.7	22404.6	164.518	57.46	1957.89	203.2
286.0	5.46390	.0494	.1172	21770.9	22475.9	164.715	55.20	1363.21	209.8
287.0	5.58103	.0658	.1176	21825.3	22545.4	164.904	53.60	1042.27	215.3
288.0	5.69852	.0828	.1180	21878.2	22613.5	165.089	52.39	843.29	220.2
289.0	5.81632	.1003	.1184	21930.1	22680.6	165.268	51.44	708.66	224.5
290.0	5.93439	.1181	.1188	21981.2	22746.9	165.445	50.66	611.90	228.6
291.0	6.05271	.1362	.1191	22031.5	22812.5	165.618	50.01	539.21	232.3
292.0	6.17125	.1546	.1194	22081.2	22877.5	165.789	49.46	482.73	235.9
293.0	6.29000	.1732	.1197	22130.4	22942.1	165.957	48.99	437.66	239.2
294.0	6.40895	.1919	.1199	22179.2	23006.2	166.123	48.58	400.91	242.4
296.0	6.64734	.2297	.1204	22275.7	23133.4	166.450	47.90	344.71	248.6
298.0	6.88633	.2679	.1209	22370.9	23259.5	166.771	47.36	303.85	254.3
300.0	7.12584	.3064	.1214	22465.2	23384.7	167.086	46.92	272.88	259.8

Table V. (Continued)

8.00 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20521.2	21068.0	160.186	131.49		
277.0	4.47336	.0000	.0996	20653.4	21212.6	160.664	132.92		
278.0	4.57436	.0000	.1018	20787.2	21359.0	161.147	134.82		
279.0	4.67757	.0000	.1041	20923.3	21508.0	161.635	137.50		
280.0	4.78307	.0000	.1065	21062.7	21660.5	162.134	141.57		
280.5	4.83671	.0000	.1078	21134.2	21738.7	162.389	144.58		
281.0	4.89096	.0000	.1091	21207.5	21818.8	162.650	148.86		
281.5	4.94586	.0000	.1104	21283.4	21901.7	162.920	155.75		
282.0	5.00145	.0000	.1119	21364.5	21989.6	163.208	170.90		
282.5	5.05830	.0017	.1167	21442.8	22075.1	163.485	79.20	35911.42	164.7
283.0	5.11707	.0075	.1182	21478.8	22118.4	163.613	67.31	8238.30	181.6
283.5	5.17636	.0143	.1190	21511.2	22158.2	163.727	62.82	4444.69	190.1
284.0	5.23600	.0215	.1197	21541.9	22196.4	163.835	60.10	2995.70	196.1
284.5	5.29592	.0292	.1202	21571.4	22233.4	163.939	58.18	2243.20	201.0
285.0	5.35605	.0371	.1207	21600.1	22269.6	164.040	56.73	1786.52	205.1
286.0	5.47689	.0538	.1214	21655.7	22340.3	164.235	54.60	1264.60	212.0
287.0	5.59836	.0711	.1221	21709.5	22409.3	164.422	53.09	977.46	217.8
288.0	5.72036	.0890	.1226	21762.0	22477.1	164.605	51.95	797.12	222.9
289.0	5.84281	.1074	.1231	21813.5	22543.9	164.784	51.04	673.92	227.4
290.0	5.96566	.1261	.1236	21864.2	22609.9	164.959	50.31	584.72	231.6
291.0	6.08886	.1451	.1240	21914.2	22675.3	165.131	49.69	517.32	235.6
292.0	6.21239	.1643	.1244	21963.6	22740.1	165.300	49.17	464.68	239.3
293.0	6.33621	.1837	.1248	22012.5	22804.6	165.468	48.72	422.50	242.8
294.0	6.46029	.2033	.1251	22061.0	22868.6	165.633	48.33	387.98	246.1
296.0	6.70916	.2429	.1258	22157.0	22995.7	165.958	47.69	334.96	252.5
298.0	6.95887	.2827	.1263	22251.9	23121.8	166.278	47.18	296.22	258.4
300.0	7.20929	.3228	.1269	22345.8	23247.0	166.592	46.76	266.74	264.1

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Table V. (Continued)

8.25 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DRD.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20435.6	20965.6	159.816	129.25		
277.0	4.47336	.0000	.0996	20565.5	21107.7	160.288	130.64		
278.0	4.57436	.0000	.1018	20697.0	21251.5	160.760	132.49		
279.0	4.67757	.0000	.1041	20830.7	21397.7	161.240	135.09		
280.0	4.78307	.0000	.1065	20967.6	21547.4	161.730	139.64		
280.5	4.83671	.0000	.1078	21037.9	21624.1	161.980	141.97		
281.0	4.89096	.0000	.1091	21109.8	21702.7	162.237	146.12		
281.5	4.94586	.0000	.1104	21184.4	21783.9	162.502	152.80		
282.0	5.00145	.0000	.1119	21263.8	21870.1	162.784	167.49		
282.5	5.05869	.0033	.1197	21335.6	21948.8	163.038	73.26	17912.90	170.5
283.0	5.11929	.0105	.1217	21389.7	21990.2	163.159	64.80	5920.38	185.0
283.5	5.18039	.0182	.1228	21401.1	22029.0	163.269	61.08	3502.65	193.1
284.0	5.24196	.0263	.1236	21431.0	22066.4	163.375	58.73	2473.41	199.1
284.5	5.30390	.0347	.1243	21459.9	22102.8	163.477	57.04	1906.85	204.0
285.0	5.36614	.0433	.1249	21488.1	22138.5	163.576	55.74	1549.90	208.2
286.0	5.49139	.0613	.1259	21542.8	22208.4	163.767	53.81	1127.35	215.3
287.0	5.61747	.0799	.1268	21595.9	22276.8	163.953	52.43	888.98	221.3
288.0	5.74425	.0990	.1275	21647.8	22344.1	164.133	51.38	732.55	226.5
289.0	5.87162	.1185	.1281	21698.7	22410.5	164.310	50.54	625.32	231.2
290.0	5.99950	.1383	.1287	21748.9	22476.2	164.483	49.88	546.70	235.6
291.0	6.12785	.1583	.1292	21798.5	22541.3	164.654	49.29	486.69	239.7
292.0	6.25662	.1786	.1297	21847.5	22605.9	164.822	48.80	439.44	243.5
293.0	6.38575	.1991	.1301	21896.1	22670.2	164.988	48.39	401.31	247.1
294.0	6.51523	.2198	.1306	21944.3	22734.1	165.152	48.02	369.92	250.6
296.0	6.77509	.2612	.1313	22039.8	22861.0	165.478	47.43	321.34	257.1
298.0	7.03601	.3030	.1320	22134.1	22987.0	165.793	46.95	285.57	263.3
300.0	7.29785	.3449	.1326	22227.6	23112.2	166.106	46.58	258.17	269.1

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Table V. (Continued)

8.50 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20355.0	20869.7	159.468	127.14		
277.0	4.47336	.0000	.0998	20482.8	21009.1	159.930	128.49		
278.0	4.57436	.0000	.1018	20612.1	21150.3	160.395	130.30		
279.0	4.67757	.0000	.1041	20743.6	21293.9	160.868	132.82		
280.0	4.78307	.0000	.1065	20878.2	21440.9	161.350	136.66		
280.5	4.83671	.0000	.1078	20947.2	21516.2	161.596	139.51		
281.0	4.89096	.0000	.1091	21017.9	21593.3	161.848	143.54		
281.5	4.94586	.0000	.1104	21091.2	21673.0	162.108	150.03		
282.0	5.00145	.0000	.1119	21169.1	21757.5	162.385	164.29		
282.5	5.06014	.0071	.1237	21231.2	21826.5	162.605	67.27	8530.55	178.7
283.0	5.12252	.0158	.1257	21263.2	21865.9	162.718	61.88	3959.90	190.4
283.5	5.18572	.0248	.1271	21293.4	21903.5	162.825	59.01	2601.46	197.9
284.0	5.24945	.0340	.1281	21322.4	21940.0	162.927	57.10	1942.21	203.6
284.5	5.31365	.0434	.1289	21350.6	21975.8	163.026	55.68	1551.88	208.5
285.0	5.37821	.0530	.1296	21378.2	22010.9	163.123	54.56	1293.82	212.6
285.5	5.44306	.0626	.1308	21431.8	22079.9	163.311	52.88	973.94	219.8
286.0	5.50826	.0726	.1318	21484.1	22147.5	163.493	51.65	783.75	225.8
286.5	5.57376	.0828	.1327	21535.2	22214.2	163.671	50.71	657.89	231.2
287.0	5.63931	.0928	.1334	21585.6	22280.1	163.845	49.95	568.56	236.0
287.5	5.70512	.1031	.1341	21635.2	22345.4	164.017	49.33	501.98	240.5
288.0	5.77121	.1133	.1347	21684.3	22410.2	164.186	48.82	450.42	244.7
288.5	5.83757	.1237	.1353	21732.8	22474.6	164.352	48.37	409.39	248.6
289.0	5.90383	.1342	.1358	21781.0	22538.7	164.517	47.99	375.97	252.3
289.5	5.97044	.1448	.1363	21828.8	22602.4	164.680	47.66	348.24	255.9
290.0	6.03708	.1553	.1372	21923.6	22729.1	165.001	47.12	304.92	262.6
290.5	6.10398	.1660	.1380	22017.4	22855.0	165.317	46.68	272.66	268.9
291.0	6.17089	.1766	.1387	22110.4	22980.2	165.628	46.33	247.74	274.9
291.5	6.23804	.1981							
292.0	6.30519	.2197							
292.5	6.37257	.2306							
293.0	6.43995	.2415							
293.5	6.50754	.2652							
294.0	6.57512	.2892							
294.5	6.64298	.3032							
295.0	6.84656	.3292							
296.0	7.11927	.3732							
298.0	7.39308								
300.0									

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Table V. (Continued)

8.78 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20279.0	20779.0	159.139	125.15		
277.0	4.47336	.0000	.0998	20404.8	20916.0	159.504	126.47		
278.0	4.57436	.0000	.1018	20532.1	21054.9	160.053	128.23		
279.0	4.67757	.0000	.1041	20661.5	21198.1	160.517	130.69		
280.0	4.78307	.0000	.1065	20793.9	21340.5	160.991	134.42		
280.5	4.83671	.0000	.1078	20861.8	21414.5	161.233	137.18		
281.0	4.89096	.0000	.1091	20931.3	21490.2	161.481	141.10		
281.5	4.94585	.0000	.1104	21003.3	21568.5	161.737	147.41		
282.0	5.00145	.0000	.1119	21078.8	21651.4	162.008	161.26		
282.5	5.06272	.0143	.1288	21128.5	21707.1	162.181	62.15	4320.06	188.4
283.0	5.12754	.0249	.1306	21158.7	21744.7	162.288	58.89	2587.55	197.6
283.5	5.19317	.0353	.1320	21187.6	21781.1	162.390	56.81	1876.78	204.3
284.0	5.25940	.0458	.1331	21215.6	21816.7	162.489	55.32	1482.22	209.7
284.5	5.32612	.0564	.1340	21243.0	21851.7	162.585	54.16	1229.56	214.3
285.0	5.39325	.0670	.1349	21269.8	21886.2	162.679	53.25	1053.39	218.4
286.0	5.52866	.0886	.1362	21322.3	21954.2	162.863	51.83	823.32	225.5
287.0	5.66503	.1106	.1373	21373.6	22021.1	163.042	50.78	679.44	231.5
288.0	5.80247	.1328	.1383	21424.0	22087.1	163.217	49.98	580.87	236.9
289.0	5.94073	.1552	.1391	21473.6	22152.5	163.388	49.30	509.09	241.9
290.0	6.07972	.1779	.1399	21522.6	22217.4	163.558	48.75	454.49	246.4
291.0	6.21936	.2008	.1406	21571.1	22281.9	163.725	48.29	411.56	250.6
292.0	6.35957	.2235	.1412	21618.2	22346.0	163.890	47.90	376.94	254.7
293.0	6.50030	.2465	.1418	21667.0	22409.8	164.054	47.56	348.42	258.5
294.0	6.64149	.2695	.1424	21714.3	22473.4	164.215	47.28	324.54	262.1
295.0	6.92517	.3158	.1434	21808.4	22599.8	164.534	46.78	286.77	269.0
298.0	7.21032	.3621	.1443	21901.5	22725.6	164.847	46.39	258.29	275.4
300.0	7.49675	.4085	.1451	21994.0	22850.7	165.157	46.07	236.05	281.5

Table V. (Continued)

9.00 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20207.3	20693.3	158.829	123.28		
277.0	4.47336	.0000	.0996	20331.1	20828.2	159.277	124.57		
278.0	4.57436	.0000	.1018	20456.5	20964.6	159.729	126.28		
279.0	4.67757	.0000	.1041	20583.9	21103.7	160.186	128.67		
280.0	4.78307	.0000	.1065	20714.3	21245.7	160.652	132.30		
280.5	4.83671	.0000	.1078	20781.1	21318.5	160.891	134.99		
281.0	4.89096	.0000	.1091	20849.4	21392.9	161.134	138.80		
281.5	4.94586	.0000	.1104	20920.2	21469.8	161.385	144.93		
282.0	5.00145	.0000	.1119	20995.5	21551.2	161.653	158.41		
282.5	5.06774	.0268	.1344	21026.8	21589.8	161.764	58.06	2409.17	199.1
283.0	5.13542	.0390	.1362	21055.3	21625.9	161.865	56.08	1713.49	206.4
283.5	5.20387	.0510	.1378	21082.9	21661.1	161.962	54.64	1349.12	212.3
284.0	5.27293	.0629	.1393	21110.0	21695.8	162.058	53.53	1120.90	217.3
284.5	5.34250	.0747	.1407	21136.5	21730.1	162.151	52.64	963.27	221.7
285.0	5.41251	.0866	.1420	21162.6	21764.0	162.243	51.90	847.35	225.6
286.0	5.55364	.1104	.1420	21213.9	21831.0	162.422	50.74	687.57	232.5
287.0	5.69602	.1344	.1432	21264.2	21897.1	162.598	49.86	582.21	238.5
288.0	5.83947	.1585	.1443	21313.7	21962.3	162.770	49.16	507.29	243.8
289.0	5.98382	.1827	.1453	21362.6	22027.4	162.939	48.60	451.21	248.8
290.0	6.12898	.2070	.1461	21410.9	22091.9	163.107	48.13	407.61	253.3
291.0	6.27485	.2313	.1469	21458.9	22156.1	163.271	47.73	372.73	257.6
292.0	6.42136	.2557	.1476	21506.4	22219.9	163.435	47.39	344.17	261.7
293.0	6.56845	.2802	.1482	21553.6	22283.5	163.596	47.09	320.36	265.5
294.0	6.71607	.3047	.1488	21600.6	22346.8	163.756	46.83	300.20	269.2
295.0	7.01272	.3538	.1499	21693.8	22473.0	164.072	46.41	267.92	276.2
296.0	7.31104	.4036	.1509	21785.3	22598.6	164.383	46.07	243.22	282.8
300.0	7.61085	.4514	.1518	21878.2	22723.8	164.691	45.79	223.70	289.0

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Table V. (Continued)

9.25 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP J/(MOL.K)	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20139.4	20612.3	158.535	121.50		
277.0	4.47336	.0000	.0996	20261.5	20745.1	158.977	122.76		
278.0	4.57436	.0000	.1018	20385.0	20879.5	159.422	124.43		
279.0	4.67757	.0000	.1041	20510.5	21016.2	159.873	126.76		
280.0	4.78307	.0000	.1065	20638.9	21156.0	160.332	130.30		
280.5	4.83671	.0000	.1078	20704.7	21227.6	160.567	132.92		
281.0	4.89096	.0000	.1091	20772.0	21300.8	160.807	136.63		
281.5	4.94586	.0000	.1104	20841.7	21376.4	161.054	142.59		
282.0	5.00662	.0318	.1392	20897.5	21438.7	161.252	56.01	2066.84	204.4
282.5	5.07671	.0462	.1411	20925.2	21474.0	161.350	54.83	1476.15	210.7
283.0	5.14767	.0600	.1427	20952.3	21508.8	161.446	53.60	1173.00	216.7
283.5	5.21934	.0735	.1440	20978.8	21543.1	161.540	52.61	983.76	221.8
284.0	5.29160	.0868	.1451	21004.9	21577.0	161.632	51.80	852.65	226.3
284.5	5.36435	.1000	.1461	21030.7	21610.6	161.722	51.13	755.72	230.4
285.0	5.43755	.1131	.1470	21056.1	21643.9	161.812	50.56	680.82	234.1
286.0	5.58510	.1393	.1485	21106.2	21710.0	161.987	49.64	572.06	240.7
287.0	5.73395	.1654	.1498	21155.4	21775.3	162.159	48.93	496.49	246.6
288.0	5.88392	.1915	.1509	21204.1	21840.2	162.328	48.35	440.72	251.9
289.0	6.03486	.2175	.1519	21252.2	21904.6	162.495	47.88	397.77	256.8
290.0	6.18666	.2436	.1528	21299.8	21968.7	162.660	47.48	363.61	261.4
291.0	6.33922	.2697	.1536	21347.2	22032.5	162.823	47.15	335.78	265.6
292.0	6.49247	.2957	.1543	21394.2	22096.0	162.984	46.86	312.65	269.7
293.0	6.64635	.3217	.1550	21440.9	22159.4	163.144	46.61	293.10	273.6
294.0	6.80080	.3477	.1557	21487.4	22222.6	163.302	46.39	276.37	277.3
296.0	7.11124	.3996	.1569	21579.8	22348.6	163.615	46.03	249.20	284.3
298.0	7.42348	.4513	.1579	21671.5	22474.1	163.924	45.74	228.08	291.0
300.0	7.73728	.5027	.1589	21762.8	22599.2	164.229	45.50	211.18	297.3

Table V. (Continued)

9.50 MOLE/DM3 ISOCHORE

TEMPERATURE	PRESSURE	ISOTHERM DERIVATIVE	ISOCHORE DERIVATIVE	INTERNAL ENERGY	ENTHALPY	ENTROPY	CV	CP	VELOCITY OF SOUND
K	MPA	DM3.MPA/MOL	MPA/K	J/MOL	J/MOL	J/(MOL.K)	J/(MOL.K)		M/S
276.0	4.37453	.0000	.0974	20075.1	20535.5	158.257	119.82		
277.0	4.47336	.0000	.0996	20135.5	20666.3	158.692	121.05		
278.0	4.57436	.0000	.1018	20317.3	20798.8	159.131	122.68		
279.0	4.67757	.0000	.1041	20441.0	20933.4	159.576	124.95		
280.0	4.78307	.0000	.1065	20567.6	21071.1	160.029	128.40		
280.5	4.83671	.0000	.1078	20632.4	21141.5	160.260	130.95		
281.0	4.89096	.0000	.1091	20698.7	21213.5	160.496	134.57		
281.5	4.94586	.0000	.1104	20767.3	21287.9	160.740	140.38		
282.0	5.01770	.0586	.1469	20797.0	21325.2	160.845	53.07	1205.58	217.7
282.5	5.09160	.0744	.1486	20823.3	21359.3	160.939	52.25	980.95	223.1
283.0	5.16623	.0896	.1500	20849.2	21393.1	161.030	51.46	836.96	228.1
283.5	5.24148	.1044	.1512	20874.8	21426.5	161.121	50.79	735.27	232.6
284.0	5.31729	.1191	.1522	20900.0	21459.8	161.210	50.21	658.93	236.7
284.5	5.39359	.1336	.1532	20925.0	21492.8	161.297	49.72	599.16	240.5
285.0	5.47030	.1480	.1540	20949.8	21525.6	161.384	49.29	550.90	243.9
286.0	5.62489	.1765	.1555	20998.7	21590.8	161.556	48.57	477.39	250.3
287.0	5.78079	.2048	.1568	21047.0	21655.5	161.724	48.01	423.76	255.9
288.0	5.93784	.2330	.1580	21094.7	21719.8	161.890	47.54	382.73	261.1
289.0	6.09589	.2610	.1590	21142.1	21783.8	162.054	47.16	350.24	265.9
290.0	6.25483	.2889	.1599	21189.1	21847.5	162.217	46.84	323.83	270.4
291.0	6.41457	.3168	.1608	21235.8	21911.0	162.377	46.56	301.90	274.7
292.0	6.57504	.3445	.1616	21282.2	21974.3	162.537	46.32	283.39	278.7
293.0	6.73616	.3722	.1623	21328.4	22037.5	162.695	46.12	267.55	282.6
294.0	6.89789	.3998	.1630	21374.5	22100.5	162.852	45.93	253.82	286.3
296.0	7.22298	.4547	.1642	21466.0	22226.3	163.162	45.63	231.22	293.4
298.0	7.54999	.5092	.1653	21557.0	22351.8	163.468	45.40	213.37	300.1
300.0	7.87886	.5633	.1664	21647.6	22477.0	163.771	45.20	198.89	306.4

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Table V. (Continued)

9.75 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	20014.0	20462.7	157.993	118.23		
277.0	4.47336	.0000	.0998	20132.8	20591.6	158.423	119.43		
278.0	4.57436	.0000	.1018	20253.0	20722.2	158.856	121.02		
279.0	4.67757	.0000	.1041	20375.1	20854.8	159.294	123.24		
280.0	4.78307	.0000	.1065	20499.9	20990.4	159.741	126.60		
280.5	4.83671	.0000	.1078	20563.8	21059.8	159.969	129.09		
281.0	4.89096	.0000	.1091	20629.1	21130.8	160.201	132.61		
281.5	4.95944	.0784	.1539	20670.1	21178.8	160.347	51.07	948.07	227.4
282.0	5.03675	.0958	.1553	20695.6	21212.2	160.438	50.71	798.62	231.8
282.5	5.11476	.1127	.1567	20720.8	21245.4	160.527	50.16	697.12	236.4
283.0	5.19341	.1292	.1579	20745.7	21278.4	160.615	49.65	622.91	240.7
283.5	5.27261	.1454	.1590	20770.4	21311.2	160.702	49.18	565.79	244.6
284.0	5.35232	.1613	.1600	20794.9	21343.9	160.788	48.78	520.17	248.3
284.5	5.43248	.1770	.1609	20819.2	21376.4	160.874	48.42	482.74	251.8
285.0	5.51305	.1926	.1617	20843.4	21408.8	160.959	48.10	451.37	255.0
286.0	5.67531	.2235	.1632	20891.2	21473.3	161.126	47.58	401.55	261.0
287.0	5.83886	.2539	.1645	20938.5	21537.4	161.292	47.12	363.56	266.4
288.0	6.00356	.2842	.1656	20985.5	21601.2	161.455	46.76	333.51	271.5
289.0	6.16926	.3142	.1667	21032.1	21664.8	161.616	46.46	309.08	276.2
290.0	6.33587	.3440	.1676	21078.4	21728.2	161.776	46.20	288.79	280.6
291.0	6.50330	.3737	.1685	21124.5	21791.5	161.935	45.98	271.65	284.8
292.0	6.67147	.4032	.1693	21170.4	21854.6	162.093	45.79	256.96	288.8
293.0	6.84032	.4325	.1701	21216.1	21917.6	162.249	45.63	244.21	292.8
294.0	7.00980	.4617	.1708	21261.6	21980.6	162.404	45.48	233.05	296.3
296.0	7.35044	.5197	.1720	21352.4	22106.2	162.712	45.24	214.41	303.4
298.0	7.69309	.5772	.1732	21442.6	22231.7	163.016	45.06	199.43	310.0
300.0	8.03746	.6341	.1743	21532.5	22357.0	163.316	44.90	187.14	316.4

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Table V. (Continued)

10.00 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	19955.1	20383.5	157.743	118.71		
277.0	4.47336	.0000	.0998	20073.3	20520.7	158.167	117.89		
278.0	4.57436	.0000	.1018	20192.0	20640.4	158.594	119.44		
279.0	4.67757	.0000	.1041	20312.4	20760.2	159.027	121.61		
280.0	4.78307	.0000	.1065	20435.6	20913.9	159.467	124.89		
280.5	4.83671	.0000	.1078	20498.8	20982.2	159.692	127.32		
281.0	4.89048	.1077	.1618	20563.9	21034.3	159.854	49.21	735.79	238.9
281.5	4.92169	.1263	.1630	20568.5	21087.0	159.941	49.17	642.83	242.3
282.0	5.06653	.1448	.1643	20593.0	21099.7	160.028	48.83	575.09	246.4
282.5	5.14896	.1627	.1654	20617.3	21132.2	160.114	48.48	523.30	250.4
283.0	5.23194	.1804	.1665	20641.5	21164.7	160.200	48.11	482.18	254.1
283.5	5.31542	.1977	.1675	20665.5	21197.0	160.284	47.79	448.50	257.7
284.0	5.39938	.2148	.1684	20689.3	21229.2	160.368	47.51	420.38	261.0
284.5	5.48371	.2317	.1693	20713.0	21261.3	160.452	47.25	396.35	264.2
285.0	5.56845	.2484	.1700	20736.5	21293.4	160.534	47.02	375.62	267.2
286.0	5.73900	.2815	.1715	20783.4	21357.3	160.698	46.62	341.50	272.8
287.0	5.91080	.3141	.1727	20829.8	21420.9	160.860	46.30	314.48	278.0
288.0	6.08371	.3464	.1739	20876.0	21484.3	161.021	46.02	292.41	282.9
289.0	6.25762	.3783	.1749	20921.9	21547.6	161.180	45.79	274.08	287.4
290.0	6.43244	.4100	.1758	20967.6	21610.8	161.338	45.59	259.50	291.7
291.0	6.60807	.4415	.1767	21013.1	21673.9	161.495	45.43	245.14	295.9
292.0	6.78445	.4727	.1775	21058.4	21736.9	161.650	45.28	233.52	299.8
293.0	6.96152	.5038	.1783	21103.6	21799.8	161.805	45.15	223.32	303.6
294.0	7.13923	.5346	.1790	21148.7	21862.7	161.958	45.04	214.28	307.2
296.0	7.49637	.5957	.1803	21238.8	21988.3	162.263	44.85	199.98	314.2
298.0	7.85555	.6562	.1815	21328.2	22113.8	162.565	44.72	188.48	320.9
300.0	8.21692	.7159	.1826	21417.5	22239.2	162.863	44.60	178.11	327.3

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Table V. (Continued)

10.25 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP J/(MOL.K)	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	19900.9	20327.7	157.504	115.27		
277.0	4.47336	.0000	.0996	20016.8	20453.2	157.923	116.42		
278.0	4.57436	.0000	.1018	20133.9	20580.2	158.345	117.94		
279.0	4.67757	.0000	.1041	20252.8	20709.2	158.772	120.06		
280.0	4.78307	.0000	.1065	20374.4	20841.0	159.207	123.26		
280.5	4.85192	.1479	.1705	20417.8	20891.2	159.362	47.69	575.70	251.5
281.0	4.93744	.1677	.1715	20441.7	20923.4	159.447	47.74	519.03	254.3
281.5	5.02351	.1874	.1726	20465.5	20955.6	159.532	47.54	474.95	257.9
282.0	5.11013	.2067	.1737	20489.2	20987.8	159.616	47.29	439.70	261.6
282.5	5.19726	.2257	.1748	20512.8	21019.9	159.700	47.04	410.74	265.1
283.0	5.28487	.2444	.1757	20536.3	21051.9	159.783	46.81	386.43	268.5
283.5	5.37293	.2627	.1766	20559.6	21083.8	159.865	46.59	365.65	271.7
284.0	5.46141	.2809	.1775	20582.9	21115.7	159.947	46.40	347.65	274.7
284.5	5.55027	.2989	.1782	20606.0	21147.5	160.028	46.22	331.85	277.6
285.0	5.63948	.3167	.1790	20629.1	21179.3	160.109	46.05	317.86	280.4
286.0	5.81891	.3518	.1803	20675.0	21242.7	160.270	45.77	294.13	285.7
287.0	5.99954	.3865	.1815	20720.6	21306.0	160.429	45.53	274.68	290.6
288.0	6.18124	.4207	.1826	20766.1	21369.1	160.587	45.33	258.42	295.3
289.0	6.36392	.4545	.1836	20811.3	21432.2	160.744	45.16	244.57	299.7
290.0	6.54747	.4880	.1846	20856.4	21495.2	160.900	45.02	232.63	303.9
291.0	6.73184	.5213	.1855	20901.4	21558.1	161.055	44.90	222.21	307.9
292.0	6.91695	.5542	.1863	20946.2	21621.0	161.209	44.79	213.03	311.7
293.0	7.10274	.5869	.1870	20991.0	21683.9	161.362	44.70	204.87	315.5
294.0	7.28917	.6194	.1878	21035.6	21746.7	161.514	44.62	197.57	319.1
296.0	7.66377	.6837	.1891	21124.7	21872.4	161.816	44.49	185.04	326.0
298.0	8.04042	.7470	.1903	21213.6	21998.0	162.115	44.39	174.66	332.5
300.0	8.41888	.8098	.1914	21302.3	22123.7	162.412	44.32	165.91	338.8

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Table V. (Continued)

10.50 MOLE/DM3 ISOCHORE

TEMPERATURE K	PRESSURE MPA	ISOTHERM DERIVATIVE DM3.MPA/MOL	ISOCHORE DERIVATIVE MPA/K	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
276.0	4.37453	.0000	.0974	19848.4	20365.0	157.277	113.90		
277.0	4.47336	.0000	.0996	19962.9	20368.9	157.681	115.02		
278.0	4.57436	.0000	.1018	20078.6	20514.2	158.108	116.51		
279.0	4.67757	.0000	.1041	20195.1	20641.6	158.530	118.58		
280.0	4.80726	.2004	.1798	20291.5	20749.3	158.871	46.44	459.59	264.8
280.5	4.89744	.2213	.1807	20314.7	20781.1	158.954	46.48	424.53	267.5
281.0	4.98812	.2421	.1818	20337.9	20813.0	159.037	46.36	395.86	270.8
281.5	5.07929	.2626	.1828	20361.1	20844.8	159.119	46.19	372.00	274.1
282.0	5.17094	.2828	.1837	20384.1	20876.6	159.201	46.02	351.78	277.4
282.5	5.26304	.3026	.1846	20407.1	20908.3	159.282	45.86	334.37	280.5
283.0	5.35556	.3222	.1855	20430.0	20940.0	159.363	45.70	319.19	283.6
283.5	5.44849	.3416	.1863	20452.8	20971.7	159.444	45.56	305.79	286.5
284.0	5.54179	.3607	.1871	20475.5	21003.3	159.524	45.42	293.87	289.3
284.5	5.63544	.3797	.1878	20498.2	21034.9	159.604	45.30	283.17	292.0
285.0	5.72942	.3984	.1885	20520.9	21066.5	159.683	45.19	273.51	294.6
286.0	5.91831	.4355	.1897	20565.5	21129.6	159.841	44.89	256.70	299.5
287.0	6.10834	.4721	.1909	20610.9	21192.6	159.998	44.83	242.54	304.2
288.0	6.29938	.5081	.1920	20655.6	21255.8	160.154	44.69	230.42	308.6
289.0	6.49136	.5438	.1929	20700.2	21318.5	160.308	44.58	219.91	312.8
290.0	6.68420	.5791	.1939	20744.8	21381.4	160.462	44.48	210.69	316.9
291.0	6.87782	.6140	.1947	20789.2	21444.2	160.615	44.40	202.54	320.8
292.0	7.07217	.6486	.1955	20833.6	21507.1	160.767	44.33	195.26	324.5
293.0	7.26719	.6830	.1963	20877.9	21570.0	160.919	44.27	188.73	328.2
294.0	7.46284	.7170	.1970	20922.1	21632.9	161.069	44.22	182.83	331.7
296.0	7.85586	.7843	.1983	21010.5	21758.7	161.369	44.14	172.57	338.5
298.0	8.25092	.8506	.1995	21098.7	21884.5	161.666	44.08	163.95	345.0
300.0	8.64779	.9160	.2007	21186.8	22010.4	161.961	44.04	156.60	351.2

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Table VI a. Saturation Properties of Liquid Ethylene with Temperature as Entry

COEXISTING PHASE PROPERTIES, LIQUID

TEMPERATURE K	PRESSURE MPA	DENSITY MOL/DM3	LATENT HEAT J/MOL	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
279.60	4.74059	10.52795	3278.0	20261.4	20711.7	158.760	46.01	475.76	265.5
279.70	4.75118	10.48835	3231.5	20282.4	20735.4	158.841	46.19	491.48	263.5
279.80	4.76179	10.44791	3183.9	20303.7	20759.4	158.923	46.37	508.49	261.4
279.90	4.77242	10.40655	3135.4	20325.3	20783.9	159.007	46.56	526.96	259.2
280.00	4.78307	10.36423	3085.8	20347.4	20808.9	159.092	46.77	547.10	257.1
280.10	4.79375	10.32086	3035.1	20369.9	20834.3	159.179	46.98	569.13	254.8
280.20	4.80446	10.27638	2983.1	20392.8	20860.3	159.268	47.20	593.32	252.6
280.30	4.81518	10.23069	2929.7	20416.2	20886.9	159.359	47.43	620.03	250.3
280.40	4.82593	10.18369	2874.9	20440.1	20914.0	159.453	47.68	649.65	248.0
280.50	4.83671	10.13527	2818.5	20464.6	20941.9	159.548	47.94	682.69	245.6
280.60	4.84751	10.08530	2760.4	20489.8	20970.4	159.646	48.22	719.76	243.1
280.70	4.85833	10.03362	2700.4	20515.6	20999.8	159.747	49.52	761.66	240.6
280.80	4.86918	9.98007	2638.2	20542.2	21030.1	159.851	48.84	809.36	238.0
280.90	4.88006	9.92443	2573.8	20569.6	21061.3	159.958	49.19	864.16	235.4
281.00	4.89096	9.86646	2506.7	20597.9	21093.6	160.069	49.57	927.73	232.7
281.10	4.90189	9.80587	2436.7	20627.3	21127.2	160.185	49.98	1002.34	229.8
281.20	4.91284	9.74228	2363.4	20657.9	21162.2	160.305	50.43	1091.08	226.9
281.30	4.92382	9.67525	2286.3	20689.9	21198.8	160.432	50.93	1198.30	223.9
281.40	4.93482	9.60422	2204.7	20723.6	21237.4	160.564	51.49	1330.29	220.7
281.50	4.94586	9.52846	2117.8	20759.1	21278.1	160.705	52.13	1496.53	217.3
281.60	4.95692	9.44697	2024.8	20796.9	21321.6	160.856	52.86	1711.94	213.7
281.70	4.96801	9.35844	1923.4	20837.6	21368.5	161.018	53.73	2001.31	209.9
281.80	4.97913	9.26091	1812.3	20882.0	21419.6	161.195	54.77	2409.04	205.7
281.90	4.99027	9.15143	1688.0	20931.2	21476.5	161.392	56.07	3022.62	201.1
282.00	5.00145	9.02511	1545.0	20987.3	21541.4	161.618	57.77	4039.98	195.8
282.10	5.01266	8.87269	1373.1	21054.1	21619.0	161.889	60.20	6014.94	189.6
282.20	5.02391	8.67252	1148.4	21140.7	21720.0	162.242	64.23	11224.83	181.2
282.30	5.03519	8.33858	776.3	21283.5	21887.3	162.831	74.60	45911.59	166.4
282.345	5.04030	7.63400	0.0	21592.2	22252.4	164.121			0.0

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Table VI b. Saturation Properties of Ethylene Vapor with Temperature as Entry

COEXISTING PHASE PROPERTIES. VAPOR

TEMPERATURE K	PRESSURE MPA	DENSITY MOL/DM3	LATENT HEAT J/MOL	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP J/(MOL.K)	VELOCITY OF SOUND M/S
279.60	4.74059	4.85732	3278.0	23013.8	23989.7	170.483	50.36	674.58	215.2
279.70	4.75118	4.89289	3231.5	22995.8	23966.8	170.394	50.54	699.49	214.9
279.80	4.76179	4.92931	3183.9	22977.4	23943.4	170.302	50.73	726.50	214.6
279.90	4.77242	4.96663	3135.4	22958.5	23919.4	170.209	50.93	755.88	214.4
280.00	4.78307	5.00492	3085.8	22939.1	23894.7	170.113	51.14	787.94	214.1
280.10	4.79375	5.04424	3035.1	22919.1	23869.4	170.015	51.36	823.07	213.8
280.20	4.80445	5.08466	2983.1	22898.5	23843.4	169.915	51.59	861.70	213.5
280.30	4.81518	5.12629	2929.7	22877.3	23816.6	169.812	51.83	904.39	213.1
280.40	4.82593	5.16921	2874.9	22855.3	23788.9	169.705	52.09	951.78	212.8
280.50	4.83671	5.21355	2818.5	22832.6	23760.4	169.596	52.37	1004.68	212.4
280.60	4.84751	5.25942	2760.4	22809.1	23730.8	169.483	52.66	1064.08	212.0
280.70	4.85833	5.30699	2700.4	22784.7	23700.2	169.367	52.97	1131.23	211.6
280.80	4.86918	5.35642	2638.2	22759.2	23668.3	169.246	53.31	1207.71	211.1
280.90	4.88006	5.40792	2573.8	22732.7	23635.1	169.121	53.68	1295.57	210.6
281.00	4.89096	5.46173	2506.7	22704.9	23600.4	168.990	54.07	1397.46	210.1
281.10	4.90189	5.51816	2436.7	22675.7	23564.0	168.854	54.50	1516.98	209.5
281.20	4.91284	5.57755	2363.4	22644.8	23525.7	168.710	54.98	1658.93	208.9
281.30	4.92382	5.64036	2286.3	22612.2	23485.1	168.559	55.50	1830.19	208.1
281.40	4.93482	5.70716	2204.7	22577.4	23442.0	168.399	56.10	2040.57	207.3
281.50	4.94586	5.77866	2117.8	22540.0	23395.9	168.228	56.76	2304.78	206.4
281.60	4.95692	5.85584	2024.8	22499.9	23346.4	168.046	57.59	2642.02	205.2
281.70	4.96801	5.94003	1923.4	22455.5	23291.9	167.846	58.44	3101.64	204.0
281.80	4.97913	6.03318	1812.3	22406.7	23231.9	167.626	59.53	3739.71	202.4
281.90	4.99027	6.13821	1688.0	22351.5	23164.5	167.380	60.88	4691.33	200.5
282.00	5.00145	6.26001	1545.0	22287.5	23086.4	167.097	62.64	6250.00	197.9
282.10	5.01266	6.40781	1373.1	22209.8	22992.1	166.756	65.14	9222.52	194.3
282.20	5.02391	6.60322	1148.4	22107.5	22868.4	166.312	69.24	16842.92	188.4
282.30	5.03519	6.93209	776.3	21937.3	22663.6	165.580	79.60	65780.89	174.8
282.348	5.04030	7.63400	0.0	21592.2	22252.4	164.121			0.0

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Table VII a. Saturation Properties of Liquid Ethylene with Pressure as Entry

COEXISTING PHASE PROPERTIES, LIQUID

PRESSURE	TEMPERATURE	DENSITY	LATENT HEAT	INTERNAL ENERGY	ENTHALPY	ENTROPY	CV	CP	VELOCITY OF SOUND
MPA	K	MOL/DM3	J/MOL	J/MOL	J/MOL	J/(MOL.K)	J/(MOL.K)		M/S
4.7700	279.877	10.41604	3146.6	20320.4	20778.3	158.988	46.52	522.62	259.7
4.7800	279.971	10.37653	3100.2	20341.0	20801.7	159.067	46.71	541.11	257.7
4.7900	280.065	10.33622	3053.0	20361.9	20825.3	159.149	46.90	561.16	255.6
4.8000	280.158	10.29504	3004.9	20383.2	20849.4	159.231	47.11	582.97	253.5
4.8100	280.252	10.25292	2955.7	20404.8	20874.0	159.315	47.32	606.79	251.4
4.8200	280.345	10.20979	2905.3	20426.9	20899.0	159.401	47.54	632.91	249.3
4.8300	280.438	10.16557	2853.8	20448.3	20924.5	159.488	47.78	661.70	247.1
4.8400	280.530	10.12020	2801.0	20472.2	20950.5	159.578	48.03	693.54	244.8
4.8500	280.623	10.07355	2746.7	20495.7	20977.1	159.669	48.29	728.96	242.6
4.8600	280.715	10.02551	2690.9	20519.6	21004.4	159.763	48.57	768.59	240.2
4.8700	280.808	9.97596	2633.5	20544.2	21032.4	159.859	48.87	813.22	237.9
4.8800	280.899	9.92474	2574.1	20569.4	21061.1	159.958	49.19	863.85	235.4
4.8900	280.991	9.87166	2512.7	20595.4	21090.7	160.059	49.53	921.74	232.9
4.9000	281.083	9.81652	2449.0	20622.2	21121.3	160.165	49.90	988.56	230.3
4.9100	281.174	9.75905	2382.8	20649.9	21153.0	160.274	50.31	1066.53	227.7
4.9200	281.265	9.69896	2313.6	20678.6	21185.9	160.387	50.75	1158.61	224.9
4.9300	281.356	9.63587	2241.0	20708.6	21220.2	160.505	51.24	1268.92	222.1
4.9400	281.447	9.56929	2164.6	20740.0	21256.2	160.629	51.78	1403.33	219.1
4.9500	281.537	9.49864	2083.6	20773.0	21294.1	160.760	52.39	1570.49	216.0
4.9600	281.628	9.42312	1997.5	20807.9	21334.3	160.899	53.09	1783.62	212.7
4.9700	281.718	9.34166	1904.3	20845.3	21377.3	161.048	53.90	2064.05	209.2
4.9800	281.808	9.25278	1803.1	20885.6	21423.9	161.210	54.86	2448.27	205.4
4.9900	281.898	9.15427	1691.2	20929.9	21475.0	161.387	56.03	3004.11	201.2
5.0000	281.987	9.04268	1564.8	20979.5	21532.4	161.587	57.52	3872.55	196.6
5.0100	282.076	8.91197	1417.3	21036.9	21599.1	161.820	59.53	5398.32	191.2
5.0200	282.165	8.74990	1235.1	21107.3	21681.1	162.106	62.54	8682.69	184.5
5.0300	282.254	8.52292	981.3	21204.8	21795.0	162.506	68.14	19766.45	174.8
5.0350	282.298	8.34704	785.7	21279.9	21883.1	162.816	74.26	44849.62	166.8
5.0400	282.343	7.91252	305.9	21467.1	22104.1	163.596	108.47	1.6291+6	139.3
5.0403	282.345	7.63400	0.0	21592.2	22252.4	164.121			0.0

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Table VII b. Saturation Properties of Ethylene Vapor with Pressure as Entry

COEXISTING PHASE PROPERTIES. VAPOR

PRESSURE MPA	TEMPERATURE K	DENSITY MOL/DM3	LATENT HEAT J/MOL	INTERNAL ENERGY J/MOL	ENTHALPY J/MOL	ENTROPY J/(MOL.K)	CV J/(MOL.K)	CP	VELOCITY OF SOUND M/S
4.7700	279.877	4.95807	3146.6	22962.8	23924.9	170.230	50.89	748.97	214.4
4.7800	279.971	4.99378	3100.2	22944.7	23901.9	170.141	51.08	778.40	214.2
4.7900	280.065	5.03031	3053.0	22926.2	23878.4	170.050	51.28	810.35	213.9
4.8000	280.158	5.06770	3004.9	22907.1	23854.3	169.957	51.49	845.16	213.6
4.8100	280.252	5.10603	2955.7	22887.6	23829.6	169.862	51.72	883.22	213.3
4.8200	280.345	5.14536	2905.3	22867.5	23804.3	169.764	51.95	925.00	213.0
4.8300	280.438	5.18579	2853.8	22846.9	23778.3	169.665	52.19	971.06	212.6
4.8400	280.530	5.22737	2801.0	22825.6	23751.5	169.562	52.46	1022.06	212.3
4.8500	280.623	5.27023	2746.7	22803.6	23723.8	169.457	52.73	1078.82	211.9
4.8600	280.715	5.31446	2690.9	22780.8	23695.3	169.349	53.02	1142.34	211.5
4.8700	280.808	5.36021	2633.5	22757.3	23665.8	169.237	53.34	1213.90	211.1
4.8800	280.899	5.40764	2574.1	22732.8	23635.3	169.121	53.67	1295.06	210.6
4.8900	280.991	5.45690	2512.7	22707.4	23603.5	169.002	54.03	1387.86	210.2
4.9000	281.083	5.50823	2449.0	22680.8	23570.4	168.878	54.42	1494.91	209.6
4.9100	281.174	5.56187	2382.8	22653.0	23535.8	168.748	54.85	1619.68	209.0
4.9200	281.265	5.61812	2313.6	22623.7	23499.5	168.613	55.31	1766.84	208.4
4.9300	281.356	5.67737	2241.0	22592.9	23461.2	168.470	55.83	1942.83	207.7
4.9400	281.447	5.74009	2164.6	22560.2	23420.8	168.320	56.40	2156.77	206.9
4.9500	281.537	5.80686	2083.6	22525.3	23377.7	168.161	57.04	2422.03	206.0
4.9600	281.628	5.87849	1997.5	22488.0	23331.8	167.992	57.83	2755.25	204.9
4.9700	281.718	5.95603	1904.3	22447.1	23281.6	167.808	58.62	3200.13	203.7
4.9800	281.808	6.04096	1803.1	22402.6	23226.9	167.608	59.62	3800.84	202.3
4.9900	281.898	6.13548	1691.2	22352.9	23166.2	167.387	60.84	4662.75	200.5
5.0000	281.987	6.24303	1564.8	22296.4	23097.3	167.136	62.38	5994.93	198.3
5.0100	282.076	6.36964	1417.3	22229.9	23016.4	166.844	64.45	8300.92	195.3
5.0200	282.165	6.52752	1235.1	22147.1	22916.2	166.483	67.52	13156.27	190.8
5.0300	282.254	6.75013	981.3	22031.1	22776.3	165.982	73.16	28930.42	183.0
5.0350	282.298	6.92371	785.7	21941.5	22668.8	165.599	79.26	63033.31	175.2
5.0400	282.343	7.35568	305.9	21724.7	22409.9	164.679	112.66	1.9403+6	144.0
5.0403	282.345	7.63400	0.0	21592.2	22252.4	164.121			0.0

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APPENDIX D

Listing of Computer Program for Table Generation

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C  MAIN PROGRAM FOR GENERATION OF TABLES IN THIS REPORT.  COEFFICIENTS
C   ARE OBTAINED FROM BLOCKDATA.
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL TT,ANAMES,QNAMES
      COMMON /COEFS/ A(20),Q(20),ANAMES(20),QNAMES(20)
      COMMON /OTHER/ COMP,DPDRHO,DPDTCK
      DIMENSION TT(27)/276.,277.,278.,279.,280.,280.5,281.,281.5,282.
     1,282.5,283.,283.5,284.,284.5,285.,286.,287.,288.,289.,290.,291.
     2,292.,293.,294.,296.,298.,300./
  159 FORMAT(5X,2HA(,I2,2H)=,F12.6,5XA6,8X2HQ(,I2,2H)=,F12.6,5XA6)
      CALL CONGEN
        WRITE (6,159)(I,A(I),ANAMES(I),I,Q(I),QNAMES(I),I = 1,20)
   66 READ(5,800,END=99) DENSIN
  800 FORMAT()
      WRITE(6,44) DENSIN
   44 FORMAT(F12.2,' MOLE/LITER ISOCHORE'/111X1H./' TEMPERATURE  PRESSUR
     1E    ISOTHERM  ISOCHORE INTERNAL  ENTHALPY   ENTROPY'5X'CV',7X'CP'
     2,4X8HVELOCITY/24X'DERIVATIVE DERIVATIVE ENERGY',41X'OF SOUND'/
     3 5X'DEG K',7X'MPA',5X'L-MPA/MOL    MPA/K',4X'J/MOL'5X5HJ/MOL.
     4 4X'J/MOL-K        J/MOL-K',8X'M/SEC'/111X1H.)
      DO 64 III=1,27
      TEMK=TT(III)
      CALL THERMO(R2KT,R1,TH1,DENSIN,TEMK,PRESS,DVD,CPS,ENTROP,ENTHAL,
     1 CVOL,ENERGY,SOUND)
      DPDRHO=1./DENSIN/COMP
      IF(DABS(TH1).EQ.1.) GO TO 22
      WRITE(6,55) TEMK,PRESS,DPDRHO,DPDTCK,ENERGY,ENTHAL,ENTROP
     1,CVOL,CPS,SOUND
   55 FORMAT(F10.1,F12.5,F11.4,F10.4,2F10.1,F10.2,2F9.2,F9.1,2F10.5)
      GO TO 64
   22 WRITE(6,55) TEMK,PRESS,DPDRHO,DPDTCK,ENERGY,ENTHAL,ENTROP,CVOL
   64 CONTINUE
      GO TO 66
   99  STOP
      END

C  ALTERNATIVE MAIN PROGRAM WHICH ENABLES THE USER TO CHOOSE THE SYSTEM
C   OF UNITS FOR THE TABLE.  CALCULATION IS ALONG ISOCHORES, WITH THE
C   INPUT BEING DENSITY, INITIAL TEMPERATURE, FINAL TEMPERATURE AND
C   TEMPERATURE INCREMENT.
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL ANAMES,QNAMES
      DOUBLE PRECISION NT,ND,NP,NH
      COMMON /UNITS/ IT,ID,IP,IH,NT,ND,NP,NH,FT,FD,FP,FH
      COMMON /COEFS/ A(20),Q(20),ANAMES(20),QNAMES(20)
      COMMON /OTHER/ COMP,DPDRHO,DPDTCK
  159 FORMAT(5X,2HA(,I2,2H)=,F12.6,5XA6,8X2HQ(,I2,2H)=,F12.6,5XA6)
      CALL CONGEN
        WRITE (6,159)(I,A(I),ANAMES(I),I,Q(I),QNAMES(I),I = 1,20)
      CALL UNIT
   66 WRITE(6,799)
  799 FORMAT(' INPUT DENSITY, INITIAL T, FINAL T AND T INCREMENT:')
  800 FORMAT()
      READ(5,800,END=99) DENS,T1,T2,TI
      WRITE(6,44) DENS,ND,NT,NP,NP,ND,NP,NT,NH,NH,NH,NT,NH,NT
      DENSIN=DENS*FD
```


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```
 44  FORMAT(F12.2,2X,A6,' ISOCHORE'/     111X1H./' TEMPERATURE  PRESSUR
    1E    ISOTHERM  ISOCHORE INTERNAL  ENTHALPY    ENTROPY'5X'CV',7X'CP
    2',4X8HVELOCITY/24X'DERIVATIVE DERIVATIVE ENERGY',42X'OF SOUND'/
    3 6X,A6,4X,A6,3X,A4,'/',A6,1X,A4,'/',A1,4X,A6,4X,A6,
    4 4X,A5,'-',A1,7X,A5,'-',A1,6X,'M/SEC'/111X,1H.)
     TT=T1-TI
 64  TT=TT+TI
     IF(TT.GT.T2) GO TO 66
     TEMK=TTT(TT)
     CALL THERMO(R2KT,R1,TH1,DENSIN,TEMK,PRESS,DVD,CPS,ENTROP,ENTHAL,
    1 CVOL,ENERGY,SOUND)
     DPDRHO=FP/DENS/COMP
     POUT=PRESS*FP
     E=ENERGY*FH
     H=ENTHAL*FH
     S=ENTROP*FH*FT
     CV=CVOL*FH*FT
     CP=CPS*FH*FT
     DPDT=DPDTCK*FP*FT
     IF(DABS(TH1).EQ.1.) GO TO 22
     WRITE(6,55) TT,POUT,DPDRHO,DPDT,E,H,S,CV,CP,SOUND
 55  FORMAT(F10.2,F12.5,F11.4,F10.4,2F10.1,F11.3,2F9.2,F9.1,2F10.5)
     GO TO 64
 22  WRITE(6,55) TT,POUT,DPDRHO,DPDT,E,H,S,CV
     GO TO 64
 99   STOP
     END

     BLOCKDATA
     DOUBLE PRECISION A,Q
     COMMON /COEFS/A(20),Q(20),ANAMES(20),QNAMES(20)
     DATA A/-.007833D0,2*0.D0,-16.9686D0,5.3439D0,.325D0,1.37617D0,0.D0
    1,1.67472D0,23.9809D0,4.82D0,.7662D0,-36.4812D0,-27.3594SD0
    2,-12.5003D0,-10.5742D0,4*0.D0/
     DATA Q/-.008369D0,-.001218D0,28.0541D0,282.3452D0,7.634D0,5.0403D0
    1,.1130D0,-.777D0,12*0.D0/
     DATA ANAMES/6HC      ,6HCOT3  ,6H       ,6HCOT2  ,6HDPDT  ,6HBETA
    1,6HKO     ,6H       ,6HB*B   ,6HA      ,6HDELTA ,6HK1     ,6HMUC
    2,6HMU1    ,6HMU2    ,6HMU3   ,6HS00    ,6HS20   ,6HS01    ,6HS21   /
     DATA QNAMES/2*6H      ,6HMOL WT,6HTC     ,6HRHOC  ,6HPC
    1,6HDPCDTC,6HSLOPDI,6HP11    ,6HALPHA ,6HP00    ,6HP20    ,6HP40
    2,6HDELTAI,6HALPHAI,6HBETA I,6HGAMMAI,6HP01    ,6HP21    ,6HP41   /
     END

     SUBROUTINE CONGEN
C THIS SUBROUTINE CALCULATES ALL QUANTITIES NOT DEPENDENT ON R OR THETA
     IMPLICIT DOUBLE PRECISION (A-H,O-Z)
     COMMON /COEFS/ A(20),Q(20)
     DATA DELPP,DELPM,DELPPH,DELPMH/1.D-6,-1.D-6,1.000001D0,.999999D0/
     EQUIVALENCE (DELI,Q(14)),(DRHOC,A(3)),(BETA,A(6)),(DELTA,A(11))
    1,(COTEE2,A(4)),(DPDT,A(5)),(DELTC,A(8)),(BESQ,A(9))
    2,(CC,A(1)),(AA,A(10)),(TCK,Q(4)),(RHOC,Q(5)),(PC,Q(6)),(XKO,A(7))
    3,(ALHI,Q(15)),(BETI,Q(16)),(GAMI,Q(17)),(P01,Q(18)),(P21,Q(19))
    4,(ALPHA,Q(10)),(P00,Q(11)),(P20,Q(12)),(P40,Q(13)),(P41,Q(20))
    5,(S00,A(17)),(S20,A(18)),(S01,A(19)),(S21,A(20))
      ALPHA = 2.D0 - A(6)*(A(11) + 1.D0    )
     IF(DABS(ALPHA).LT.1.D-6) ALPHA=1.D-6
       GAMMA = BETA*(DELTA - 1.D0)
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      DELI = 0.50D0
      IF (DELI.LT.-BETA)DELI=-BETA
       ALMI = ALPHA - DELI
       BETI = BETA + DELI
        GAMI = GAMMA - DELI
      IF(ALMI.LE.DELPPH.AND.ALMI.GE.DELPMH) ALMI=1.000001D0
      IF (ALMI.LE.DELPP.AND.ALMI.GE.DELPM) ALMI = .000001D0
       DELPC = Q(7)*DELTC
      ERR = 2.D0*BETA*DELTA - 1.D0
      P00 = (BETA*(DELTA-3.D0)-BESQ*ALPHA*GAMMA)/(2.D0*
     1 BESQ*BESQ*(2.D0-ALPHA)*(1.D0-ALPHA)*ALPHA)
      P20=-(BETA*(DELTA-3.)-BESQ*ALPHA*ERR)/(2.*BESQ*(1.-ALPHA)*(ALPHA))
      P40=(ERR-2.)/2./ALPHA
      S00 = (2.-ALPHA)*P00
      S20 = -BETA*(DELTA-3.)/2./BESQ/ALPHA
       IF (XK0.LE.0.D0)XK0 = .0001D0
      DA = Q(1)
      DB = Q(2)
       RA = DA/(1.D0 - BESQ)
       RB = DB/(1.D0 - BESQ)
      SW0 = S00+S20
       SS1 =  AA*XK0*SW0*RA**(1. - ALPHA)
       SS2 =  AA*XK0*SW0*RB**(1. - ALPHA)
      D1 = CC*(SS1-SS2)
       P01 = (BETA*(DELTA-3.D0)-3.D0*DELI-A(9)*ALMI*GAMI)
     1 /(2.D0*A(9)*A(9)*(2.D0-ALMI)*(1.D0-ALMI)*ALMI)
       P21 = -((BETA*(DELTA-3.D0)-3.D0*DELI-A(9)*ALMI*ERR)/
     1  (2.D0*A(9)*(1.D0-ALMI)*ALMI))
      P41 = (.5*ERR - 1.)/ALMI
      S01 = (2.-ALMI)*P01
      S21 = -(BETA*DELTA-3.*BETI)/2./BESQ/ALMI
        PTW = P01 + P21 + P41
      SW1 = S01+S21
       SSW1 = AA*A(12)*(RA**(1.D0-ALPHA+DELI))*SW1
       SSW2 = AA*A(12)*(RB**(1.D0-ALPHA+DELI))*SW1
      D2 = CC*(SSW1-SSW2)
      Q(9) = Q(8)*.9905D0 + (D1+D2)/(DB-DA)
      RETURN
      END

      SUBROUTINE THERMO (RHO2KT,R1,TH1,D,T,PRESS,DVDPT,CP,
     2 ENTROP,ENTHAL,CV,ENERGY,SOUND)
C CALCULATES ALL THERMODYNAMIC PROPERTIES, BOTH IN 1- AND 2-PHASE
C   REGION, FOT GIVEN DENSITY AND TEMPERATURE.
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON /OTHER/ COMP,DPDRHO,DPDTCK
      COMMON /COEFS/ A(20),Q(20)
      DIMENSION S(2),SD(2)
      EQUIVALENCE (COT3,A(2)),(DRHOC,A(3)),(BETA,A(6)),(DELTA,A(11))
     1,(COT2,A(4)),(DPDT,A(5)),(XNWT,Q(3)),(DELTC,A(8)),(BESQ,A(9))
     2,(CC,A(1)),(AA,A(10)),(TCK,Q(4)),(RHOC,Q(5)),(PC,Q(6))
     3,(ALPHA,Q(10)),(XK1,A(12)),(DELI,Q(14)),(FAC,Q(7)),(XK0,A(7))
     4,(ALMI,Q(15)),(P11,Q(9)),(P1W,Q(18)),(P2W,Q(19)),(P4W,Q(20))
     5,(P00,Q(11)),(P20,Q(12)),(P40,Q(13)),(S00,A(17)),(S20,A(18))
      IFLAG = 0
      XK(1)=A(7)
      XK(2)=A(12)
    8   TER = 2.D0*BETA*DELTA - 1.D0
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      TEE=(T-TCK)/TCK
      TSTAR=TEE+1.D0
      DTSTIN=1.D0-(1.D0/TSTAR)
      RHO=D/RHOC
      CALL CONVER(RHO,TEE,AMU,TH1,R1,RHO1,S,RHODI,ER)
      TT1=TH1*TH1
      PTW=P1W+P2W*TT1+P4W*TT1*TT1
      P1=AA*XKO*(R1**(2.D0-ALPHA))*(P00+TT1*(P20+TT1*P40))
      P3=RHODI*AMU+PTW*AA*XK1*(R1**(2.D0-ALPHA+DELI))
      P4=DTSTIN*(DPDT+DTSTIN*(COT2+DTSTIN*(COT3)))
      PBAR=TSTAR*(P1+P3+P4+1.D0)
      PRESS=PBAR*PC
           IF(IFLAG.EQ.1) RETURN
      PT=DPDT+2.D0*COT2*DTSTIN+3.D0*COT3*DTSTIN*DTSTIN
      UD=A(14)+2.D0*A(15)*DTSTIN+3.D0*A(16)*DTSTIN*DTSTIN
      UFUNCT=S(1)+P11*AMU+PT-RHO*UD+S(2)
      ENERGY=1.D3*(PC*UFUNCT)/RHO/RHOC
      CALL AUX(R1,TH1,D2PDT2,D2PDMT,RHO2KT,AA,XK,SD,CVCOEX)
      IF(DABS(TH1).EQ.1.D0) RHO2KT=1.D30
      DVDPT=-((RHO2KT*RHOC**2)/((D**3)*PC*TSTAR))
      COMP=RHO2KT/PC/RHO**2
      DPDRHO=1./D/COMP
      CV1=2.DC*P11*D2PDMT/RHO2KT
      CV2=(D2PDMT*D2PDMT)/RHO2KT
      D2PZER=2.D0*COT2+6*COT3*DTSTIN
      D2MZER=2.D0*A(15)+6.DC*A(16)*DTSTIN
      CV3=RHO*D2MZER
      CV4=P11*P11/RHO2KT
      CVS=(D2PZER-CV3-CV1-CV2-CV4+D2PDT2)/TSTAR**2
      CVCOEX=(CVCOEX*AA)/((1.D0-BESQ)**2)
      IF(DABS(TH1).EQ.1.D0) CVS=(D2PZER-CV3+CVCOEX)/TSTAR**2
      CV=1.D3*PC*CVS/D/TCK
      TAU=(-1.D0)/TSTAR
      DPDTR=PT+P11*(AMU-(RHO/RHO2KT))+S(1)+S(2)-RHO*D2PDMT/RHO2KT
      DPDTR=PBAR-(TAU*DPDTR)
      DPDTCK=DPDTR*PC/TCK
      CP=(RHO2KT*DPDTR**2/RHO**2+CVS)*PC*1.D3/D/TCK
      ENHOL=PRESS/PC/TSTAR-(TAU*UFUNCT)
      ENTHAL=1.D3*PC*TSTAR*ENHOL/RHOC/RHO
      UZERO=A(13)+DTSTIN*(A(14)+DTSTIN*(A(15)+DTSTIN*A(16)))
      IF(DABS(TH1).EQ.1.D0)   GO TO 44
      SOUND=-CP/CV/D/D/DVDPT/XMWT
      SOUND=DSQRT(DABS(SOUND))*1.D3
   44 ENTROP=(ENHOL-RHO*(UZERO+AMU))*PC*1.D3/RHO/RHOC/TCK
   20 CONTINUE
      RETURN
      ENTRY PRES(R1,TH1,D,T,PRESS)
      IFLAG = 1
      GO TO 8
      END
```


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```
      SUBROUTINE AUX(R1,TH1,D2PDT2,D2PDMT,D2PDM2,AA,XK,SD,CVCOEX)
C CALCULATES SECOND DERIVATIVES. IS CALLED BY THERMO
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /COEFS/ A(20),Q(20)
       DIMENSION XK(2),S(2), SD(2),W(2),Y(2),Z(2),COEX(2)
      EQUIVALENCE (CC,A(1)),(BETA,A(6)),(BESQ,A(9)),(DELTA,A(11))
     1,(ALPHA,Q(10)),(S00,A(17)),(S20,A(18)),(S01,A(19)),(S21,A(20))
        DELI = 0.D0
       S(1)=S00+S20*TH1*TH1
       S(2)=S01+S21*TH1*TH1
       SD(1) = 2.*TH1*S20
       SD(2) = 2.*TH1*S21
        WW = 0.D0
        YY = 0.D0
        ZZ = 0.D0
         GAMMA = BETA*(DELTA - 1.D0)
       TT1 = TH1*TH1
        TER = 2.D0*BETA*DELTA - 1.D0
       G = (1.+(BESQ*TER-3.)*TT1 - BESQ*(TER-2.)*TT1*TT1)
        CVCOEX = 0.D0
         DO 30 I = 1,2
         ALHI = ALPHA - DELI
         BETI = BETA + DELI
         GAMI = GAMMA - DELI
        W(I)=(1.-ALHI)*(1.-3.*TT1)*S(I)-BETA*DELTA*(1.-TT1)*TH1*SD(I)
        W(I) = (W(I) *(R1**(-ALHI)))/G
        W(I) = W(I)*XK(I)
        WW = WW + W(I)
       Y(I) = BETI*(1.D0-3.D0*TT1)*TH1 - BETA*DELTA*(1.D0-TT1)*TH1
        Y(I) = (Y(I) *(R1**(BETI - 1.D0)))*XK(I)/G
        YY = YY + Y(I)
         Z(I) = 1.D0 - BESQ*(1.D0 - (2.D0*BETI))*TT1
        Z(I) = (Z(I) *(R1**(-GAMI)))*XK(I)/G
        ZZ = ZZ + Z(I)
        A1 = (BETA*(DELTA-3.D0)-3.D0*DELI-BESQ*ALHI*GAMI)
     1 /(2.D0*BESQ*BESQ*(2.D0-ALHI)*(1.D0-ALHI)*ALHI)
        A2 = 1+((BETA*(DELTA-3.D0)-3.D0*DELI-BESQ*ALHI*TER)/
     1   (2.D0*BESQ*(1.D0-ALHI)*ALHI))
        A2 = - A2
        A4 = 1.D0+((TER-2.D0)/(2.D0*ALHI))
        F1 = A1 + A2 + A4
        COEX(I) = ((2.D0 - ALHI)*(1.D0 - ALHI)*(R1**(-ALHI))*F1*XK(I))
        CVCOEX = CVCOEX + COEX(I)
        DELI = 0.5D0
30       CONTINUE
        D2PDT2 = AA*WW
        D2PDMT = YY + AA*CC*WW
        D2PDM2 = ZZ/AA + 2.D0*CC*YY + (CC**2)*AA*WW
       RETURN
       END

      SUBROUTINE SS(R,TH,S,SD)
C CALCULATES THE PARAMETRIC PART OF THE ENTROPY FUNCTION
C   FOR GIVEN R AND THETA.
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION S(2),SD(2)
      COMMON /COEFS/ A(20),Q(20)
      EQUIVALENCE (ALPHA,Q(10)),(BETA,A(6)),(BESQ,A(9)),(DELTA,A(11))
     1,(DELI,Q(14)),(ALHI,Q(15)),(BETI,Q(16)),(GAMI,Q(17)),(P00,Q(11))
     2,(P01,Q(18)),(S00,A(17)),(S20,A(18)),(S01,A(19)),(S21,A(20))
      TT = TH*TH
      S(1)= S00 + S20*TT
      SD(1) = 2.*S20*TH
      S(2) = S01 + S21*TT
      SD(2) = 2.*S21*TH
      S(1)=S(1)*A(10)*A(7)*R**(1.-ALPHA)
      S(2)=S(2)*A(10)*A(12)*R**(1.-ALHI)
      RETURN
      END
```


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```
      SUBROUTINE CONVER(RHO,TEE,AMU,TH1,R1,RHO1S,S1,RHODI,ERROR1)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /COEFS/ A(20),Q(20)
      DIMENSION S1(2),SD(2)
      EQUIVALENCE(BETA,A(6)),(DELTA,A(11)),(XK1,A(12)),(CC,A(1))
     1 ,(ALHI,Q(15)),(ALPHA,Q(10)),(BESQ,A(9)),(P11,Q(9))
     2 ,(DELI,Q(14)),(P1W,Q(18)),(P2W,Q(19)),(P4W,Q(20))
     3,(AA,A(10)),(XKO,A(7)),(S00,A(17)),(S20,A(18)),(BETI,Q(16))
      TSTAR = TEE+1.DO
       DTSTIN = 1.DO -  (1.DO/TSTAR)
      R1=DTSTIN
      IF(DTSTIN.LT.O.) R1=DTSTIN/(1.-BESQ)
      TH1=O.
      IF(DTSTIN.LT.O.) TH1=1.
      CALL SS(R1,TH1,S1,SD)
      RHODI = 1.DO + P11*DTSTIN
      RHODIT = RHODI + CC*(S1(1)+S1(2))
      DRHO = RHO - RHODIT
      AMU = O.DO
      IF(DTSTIN.GT.O.DO) GO TO 1
      RHO1CO = XKO*R1**BETA + XK1*R1**BETI
      TWOFAZ = RHO1CO
      IF (DABS(DRHO).GT.TWOFAZ) GO TO 1
      RHO1S = DSIGN(RHO1CO,DRHO) + CC*S1(1)
      TH1 = DSIGN(1.DO,DRHO)
      ERROR1 = 1.DO
      GO TO 999
    1 CONTINUE
      IF(DRHO.NE.O.DO) GO TO 2
      TH1 = O.DO
      R1 = DTSTIN
      RHO1S = CC*S1(1)
    2 CONTINUE
C RULE FOR FIRST PASS
       Y1 = DTSTIN
        DEN1 = RHO - RHODIT
      CALL RTHETA(R1,TH1,DEN1,Y1)
      TT=TH1*TH1
       AMU = AA* R1**(BETA*DELTA)*TH1*(1.DO-TT)
      Y1 = DTSTIN + CC*AMU
      CALL SS(R1,TH1,S1,SD)
        RHOWEG =  XK1*(R1**(DELI+BETA))*TH1 + CC*S1(2)
      RHO1S = DEN1 + CC*S1(1) + RHOWEG
      ERROR1 = RHO - RHODI - RHO1S
      IF( DABS(ERROR1).LT.1.D-5 ) GO TO 999
C RULE FOR SECOND PASS
      DEN12 = RHO - RHODI     - CC*S1(1) + RHOWEG
        IF (DEN12.EQ.DEN1) DEN12 = DEN1 - 1.D-06
      CALL RTHETA(R1,TH1,DEN12,Y1)
      TT = TH1*TH1
       AMU = AA* R1**(BETA*DELTA)*TH1*(1.DO-TT)
      Y1 = DTSTIN + CC*AMU
      CALL SS(R1,TH1,S1,SD)
        RHOWEG =  XK1*R1**(DELI+BETA)*TH1 + CC*S1(2)
      RHO1S2 = DEN12 + CC*S1(1) + RHOWEG
      ERROR2 = RHO - RHODI - RHO1S2
     *IF( DABS(ERROR2).GT.1.D-5 ) GO TO 998
      ERROR1 = ERROR2
      RHO1S = RHO1S2
      GO TO 999
  998 CONTINUE
C RULE FOR NTH PASS
       DEN2 = DEN12
      DO 44 ISIG = 1,10
      SLOPE = (ERROR2-ERROR1)/(DEN2 -DEN1)
        HOLD = DEN2
      DEN2 = DEN1 - (ERROR1/SLOPE)
      CALL RTHETA(R1,TH1,DEN2,Y1)
      TT = TH1*TH1
```


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```
      AMU = AA* R1**(BETA*DELTA)*TH1*(1.D0-TT)
      Y1 = DTSTIN + CC*AMU
      CALL SS(R1,TH1,S1,SD)
        RHOWEG =  XK1*R1**(DELI+BETA)*TH1 + CC*S1(2)
      RHO1S = DEN2 + CC*S1(1) + RHOWEG
      ERROR1 = ERROR2
      ERROR2 = RHO - RHODI - RHO1S
      IF( DABS(ERROR2).LT.1.D-6 ) GO TO 999
      DEN1 = HOLD
   44 CONTINUE
      IF(DABS(ERROR2).GT.1.D-6) WRITE (6,66) ERROR2,RHO,DTSTIN,DEN2,CC
   66 FORMAT(1X,8F9.5)
  999 CONTINUE
      RETURN
      END

      SUBROUTINE RTHETA(R,THETA, RHO,TEE )
CC    THIS VERSION WILL FIT DATA FOR THETA GT 1.0 AND LT 1.000001 AS IF M
CC    SOLVES     RHO = EM*THETA*(R**BETA)
CC    AND        TEE = R*(1.D0-BESQ*THETA*THETA)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /COEFS/ A(20),Q(20),QQ(20)
      EQUIVALENCE (BETA,A(6)),(EM,A(7)),(BESQ,A(9))
      IF(EM.LE.0.D0 .OR. BESQ.LE.1.D0) GO TO 600
      ABSRHO = DABS( RHO )
      IF(ABSRHO .LT. 1.D-12 ) GO TO 600
      BEE = DSQRT(BESQ)
      IF(DABS(TEE) .LT. 1.D-12) GO TO 495
      IF( TEE .LT. 0.D0 ) Z = 1.D0-(1.D0-BEE)*TEE/(1.D0-BESQ)
     1  *(EM/ABSRHO)**(1.D0/BETA)
      IF(TEE.GT.0.D0) Z = (1.D0+TEE*(EM/BEE/ABSRHO)**(1.D0/BETA))**-BETA
      IF( Z.GT.1.00234D0*BEE ) GO TO 496
      C = -RHO*BEE/EM/DABS(TEE)**BETA
      Z = DSIGN(Z,RHO)
  100 DO 500 N = 1, 16
      Z2 = Z*Z
      Z3 = 1.D0 - Z2
      DZ = Z3*(Z+C*DABS(Z3)**BETA)/(Z3+2.D0*BETA*Z2)
      Z = Z - DZ
      IF(DABS(DZ/Z) .LT. 1.D-12) GO TO 498
  500 CONTINUE
  601 WRITE(6,450) R,THETA, RHO,TEE,BETA,EM,BESQ
      IF(DABS(THETA).GT.1.0001) THETA=THETA/DABS(THETA)
        RETURN
  498 THETA = Z/BEE
      R = TEE/(1.D0-Z*Z)
      R = DABS(R)
        RETURN
  495 THETA = DSIGN(1.D0,RHO)/BEE
      R = (RHO/(EM*THETA))**(1.D0/BETA)
        RETURN
  496 THETA = DSIGN(1.,RHO)
        R     = TEE / ( 1.0D0 - BESQ )
      R = DABS(R)
        RETURN
  600 IF(DABS(TEE) .LT. 1.D-12) GO TO 601
      IF(TEE.LT.0.D0) GO TO 496
        THETA = 1.D-12
        R     = TEE
  450 FORMAT(2X,'RTHETA DOES NOT CONVERGE' , 7(1X, E12.6) )
      RETURN
        END
```


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```
C  SUBROUTINE SATDEN CALCULATES THE VAPOR PRESSURE AND THE
C   SATURATED LIQUID AND VAPOR DENSITIES AT THE INPUT TEMPERATURE
      SUBROUTINE SATDEN(T,DL,DV,PRESS)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
     COMMON /OTHER/ COMP,DPDRHO,DPDTCK
     COMMON /COEFS/ A(20),Q(20)
     DIMENSION S(2),SD(2)
     EQUIVALENCE (COT3,A(2)),(DRHOC,A(3)),(BETA,A(6)),(DELTA,A(11))
    1,(COT2,A(4)),(DPDT,A(5)),(XMWT,Q(3)),(DELTC,A(8)),(BESQ,A(9))
    2,(CC,A(1)),(AA,A(10)),(TCK,Q(4)),(RHOC,Q(5)),(PC,Q(6))
    3,(ALPHA,Q(10)),(XK1,A(12)),(DELI,Q(14)),(FAC,Q(7)),(XKO,A(7))
    4,(ALHI,Q(15)),(P11,Q(9)),(P1W,Q(18)),(P2W,Q(19)),(P4W,Q(20))
    5,(P00,Q(11)),(P20,Q(12)),(P40,Q(13)),(S00,A(17)),(S20,A(18))
    6,(S01,A(19)),(S21,A(20)),(BETI,Q(16))
      ERR = 2.DO*BETA*DELTA - 1.DO
     TEE=(T-TCK)/TCK
     TSTAR=TEE+1.DO
     DTSTIN=1.DO-(1.DO/TSTAR)
     D1=1.+P11*DTSTIN
     RR=DTSTIN/(1.-BESQ)
     D2=XKO*RR**BETA + XK1*RR**BETI
     D3=CC*AA*(XKO*(S00+S20)*RR**(1.-ALPHA) + XK1*(S01+S21)*
    1 RR**(1.-ALHI))
     RHOL=D1+D2+D3
     RHOV=D1-D2+D3
     DL=RHOL*RHOC
     DV=RHOV*RHOC
     CALL CONVER(RHOL,TEE,AMU,TH1,R1,RHO1,S,RHODI,ER)
     PTW=P1W+P2W+P4W
     P1=AA*XKO*(R1**(2.DO-ALPHA))*(P00+P20+P40)
     P3=RHODI*AMU+PTW*AA*XK1*(R1**(2.DO-ALPHA+DELI))
     P4=DTSTIN*(DPDT+DTSTIN*(COT2+DTSTIN*(COT3)))
     PBAR=TSTAR*(P1+P3+P4+1.DO)
     PRESS=PBAR*PC
     RETURN
     END

     SUBROUTINE DFIND(D,P,DGUESS,T,DVDPT)
C THIS SUBROUTINE WILL CALCULATE BY ITERATION THE DENSITY FOR A
C   GIVEN PRESSURE AND TEMPERATURE.  AN INITIAL GUESS FOR THE
C   DENSITY ("DGUESS") IS ALSO REQUIRED.
     IMPLICIT DOUBLE PRECISION(A-H,O-Z)
     DIMENSION S(2),SD(2),XK(2)
     COMMON /COEFS/ A(20),Q(10)
     XK(1)=A(7)
     XK(2)=A(12)
     DD = DGUESS
     VOLI = 1./DD
     TT = T
     DYLIM = .0001
     DO 10 J=1,12
     CALL PRES(R1,TH1,DD,TT,PRESS)
     DY=(P-PRESS)
     CALL AUX(R1,TH1,D2PDT2,D2PDMT,RHO2KT,A(10),XK,S,SD,CVCOEX)
     TSTAR=T/(Q(4)+A(8))
      DVDP=-((RHO2KT*(Q(5)+A(3))**2)/((DD**3)*(Q(6)+Q(7)*A(8))*TSTAR))
     IF(DVDP.LT.-2.DO) DVDP=-2.DO
     IF(DVDP.GT.1.D-2) DVDP=1.D-2
      DELV = DY*DVDP
      VOL = VOLI + DELV*.6DO
      DD = 1.DO/VOL
      VOLI = 1.DO /DD
      IF(DABS(DY).LT.DYLIM) GO TO 81
  10  CONTINUE
     WRITE(6,1) P,PRESS,DGUESS,DD,DVDP,DELV
   1  FORMAT(' NO CONVERGENCE:',6F12.5)
  81  D = DD
     RETURN
     END
```


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```
C THE FOLLOWING 2 SUBROUTINES FORM A PACKAGE ALLOWING THE USER TO
C   OPERATE IN A SYSTEM OF UNITS OF HIS CHOICE.
      SUBROUTINE UNIT
C THIS SUBROUTINE QUERIES THE USER AS TO HIS CHOICE OF UNITS AND SETS
C  INTERNAL PARAMETERS APPROPRIATELY.  THE INTERNAL UNITS OF THE PROGRAM
C  ARE TEMPERATURES IN K, DENSITIES IN MOL/CM3, ALL OTHER QUANTITIES
C  CALCULATED IN DIMENSIONLESS UNITS AND DIMENSIONED AT OUTPUT TIME.
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION NT,ND,NP,NH,NNT,NND,NNP,NNH
      COMMON /UNITS/ IT,ID,IP,IH,NT,ND,NP,NH,FT,FD,FP,FH
      DIMENSION FFD(4),FFP(5),FFH(6),NNT(4),NND(4),NNP(5),NNH(6)
      DATA FFD/.03564541D0,35.64541D0,1.D0,.5709853D0/
      DATA FFP/1.D0,10.D0,9.869232667D0,145.03773800,10.1971D0/
      DATA FFH/2*.03564541D0,1.D0,8.51379D-3,.238845900,.01532476D0/
      DATA NNT/1HK,1HC,1HR,1HF/
      DATA NND/6HKG/M3 ,6HG/CM3 ,6HMOL/L ,6HLB/FT3/
      DATA NNP/6H MPA  ,6H BAR  ,6H ATM  ,6H PSI  ,6HKG/CM2/
      DATA NNH/6HKJ/KG ,6H J/G  ,6HJ/MOL ,6HCAL/G ,7HCAL/MOL,6HBTU/LB/
      DATA A1,A2,A3,A4/8HTEMPERAT,7HDENSITY
     1,8HPRESSURE, 8HENERGY   /
      WRITE(6,11) A1
   30 WRITE(6,12)
      READ(5,10,END=99) IT
      IF(IT.EQ.0) STOP
      IF(IT.GT.4) GOTO 30
      NT=NNT(IT)
      WRITE(6,11) A2
   31 WRITE(6,13)
      READ(5,10,END=99) ID
      IF(ID.GT.4 .OR. ID.LT.1) GOTO 31
      ND=NND(ID)
      FD=FFD(ID)
      WRITE(6,11) A3
   32 WRITE(6,14)
      READ(5,10,END=99) IP
      IF(IP.GT.5 .OR. IP.LT.1) GOTO 32
      NP=NNP(IP)
      FP=FFP(IP)
      WRITE(6,11) A4
   33 WRITE(6,15)
      READ(5,10,END=99) IH
      IF(IH.GT.6 .OR. IH.LT.1) GOTO 33
      NH=NNH(IH)
      FH=FFH(IH)
      RETURN
   99 STOP
   10 FORMAT()
   11 FORMAT(' ENTER UNITS CHOSEN FOR ',A8)
   12 FORMAT(' CHOOSE FROM 1=DEG K, 2=DEG C, 3=DEG R, 4=DEG F')
   13 FORMAT(' CHOOSE FROM 1=KG/M3, 2=G/CM3, 3=MOL/L, 4=LB/FT3')
   14 FORMAT(' CHOOSE FROM 1=MPA, 2=BAR, 3=ATM, 4=PSIA, 5=KG/CM2')
   15 FORMAT(' CHOOSE FROM 1=KJ/KG, 2=J/G, 3=J/MOL, 4=CALORIES/G, 5=CALO
     1RIES/MOL, 6=BTU/LB')
      END
      FUNCTION TTT(T)
C FUNCTION TO CONVERT INPUT TEMPERATURES IN EXTERNAL UNITS TO DEG K
      DOUBLE PRECISION T,TTT,FT,FD,FP,FH,NT,ND,NP,NH
      COMMON /UNITS/ IT,ID,IP,IH,NT,ND,NP,NH,FT,FD,FP,FH
      GO TO (1,2,3,4),IT
    1 TTT=T
      FT=1.
      RETURN
    2 TTT=T+273.15D0
      FT=1.
      RETURN
    3 TTT=T/1.8D0
      FT=.555555555556D0
      RETURN
    4 TTT=(T+459.67D0)/1.8D0
      FT=.555555555556D0
      RETURN
      END
```


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Appendix E. Units and Conversion Factors

Units used in the tables

Pressure - MPa
Temperature - K
Density - mol/dm^3
Energy, Enthalpy - J/mol
Entropy - J/(mol·K)
Specific heat - J/(mol·K)
Speed of sound - m/s

Molecular weight of ethylene M = 28.0541
Gas constant* R = 8.31434 J/(mol

Reduction Factors

Pressure

MPa to	Multiply table value by
Pa	10^6
bar	10
atmosphere	9.869233
psi, lbf/in^2	145.037738

Density

mol/dm^3 to	Multiply table value by
kg/m^3	28.0541
lbm/ft^3	1.7513585

Energy, Enthalpy

J/mol to	Multiply table value by
kJ/kg	0.0356454
BTU/lbm	0.01532476

Entropy, Specific heats

J/(mol.K) to	Multiply table value by
kJ/(kg.k)	0.0356454
BTU/(lbm.R)	0.00851375

Temperature

K to	Transform table value by
°C	$(T,°C) = (T,K) - 273.15$
°F	$(T,°F) = \frac{9}{5}[(T,K) - 273.15] + 32$
R	$(T,R) = \frac{9}{5}(T,K)$

Speed of sound

m/s to	Multiply table value by
ft/s	3.28083

*The actual value of the gas constant is not required for the programs in this Tech Note. The value given here is that used in reducing the original Burnett PVT data (ref. 3, 18) and in NBS Tech Note 1045 (ref. 5).

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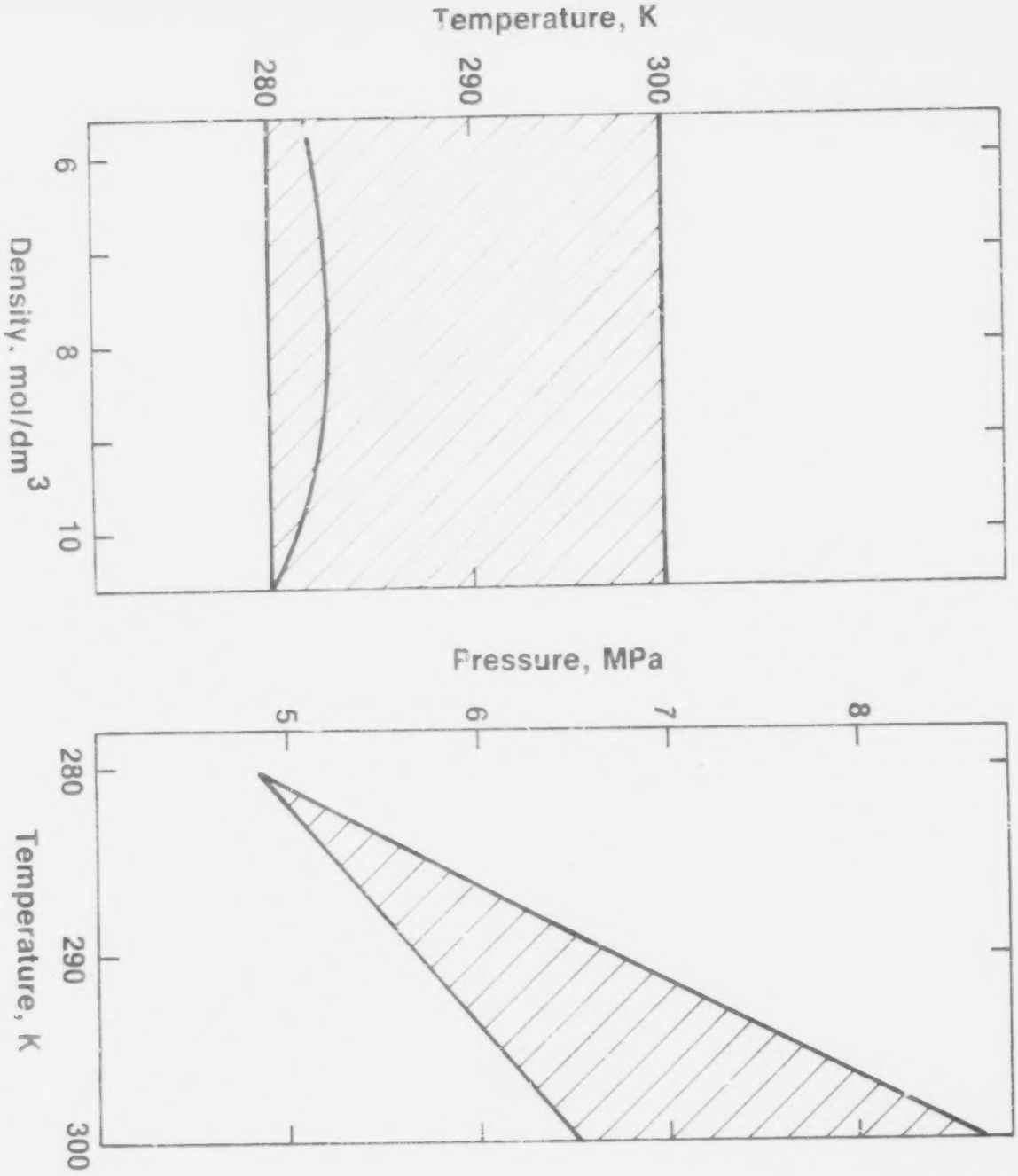

Fig. 1 Range of validity of the present formulation. Left: in temperature - density space. Right: in pressure-temperature space.

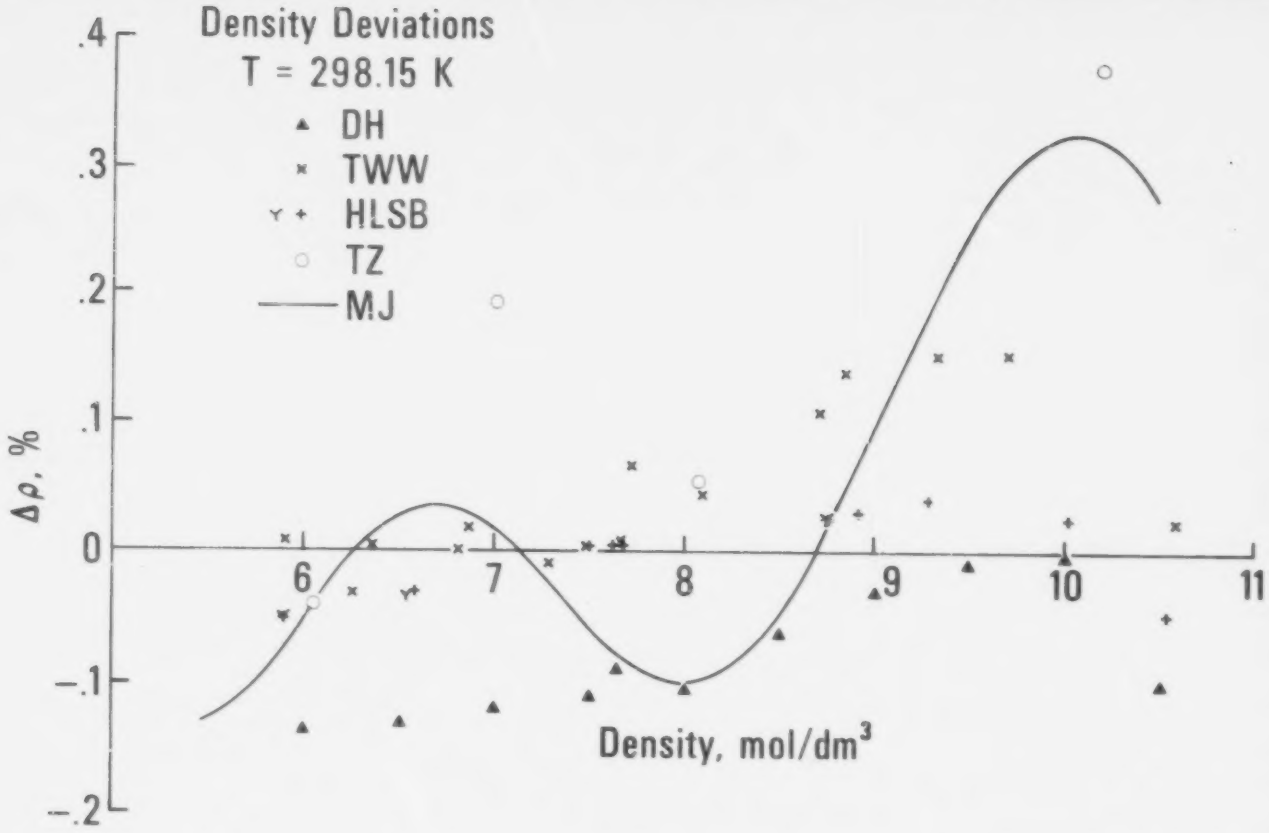

Fig. 2 Density deviation, in %, between the experimental PVT data and the present formulation, if compared at the same pressure at 298.15 K. Δ DH [10]; x TWW [11]; + HLSB [3], 99.993% pure; Y HLSB [3], 99.999% pure; o TZ [12,13]; —— MJ [5].

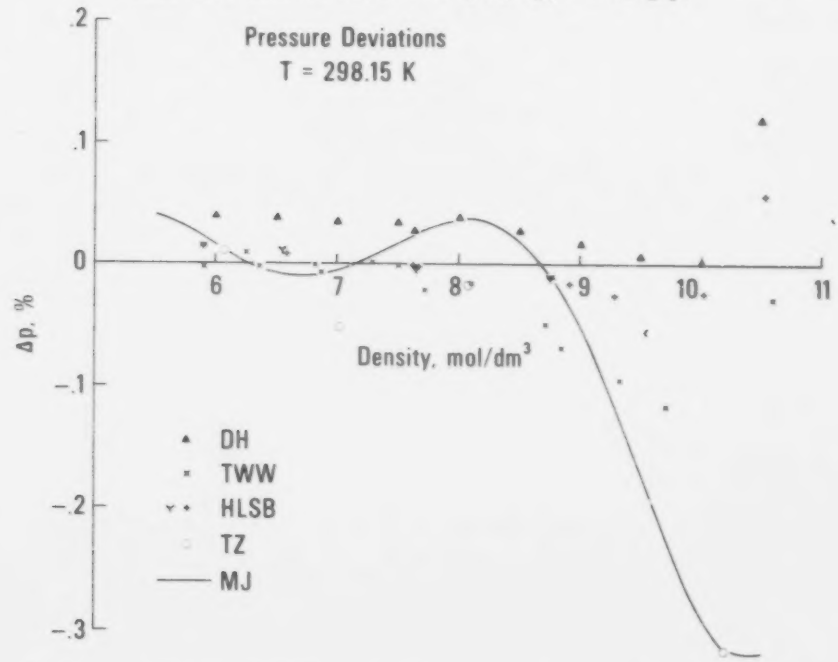

Fig. 3 Pressure deviations, in %, between the experimental PVT data and the present formulation, if compared at the same density at 298.15 K. Symbols as in Fig. 2.

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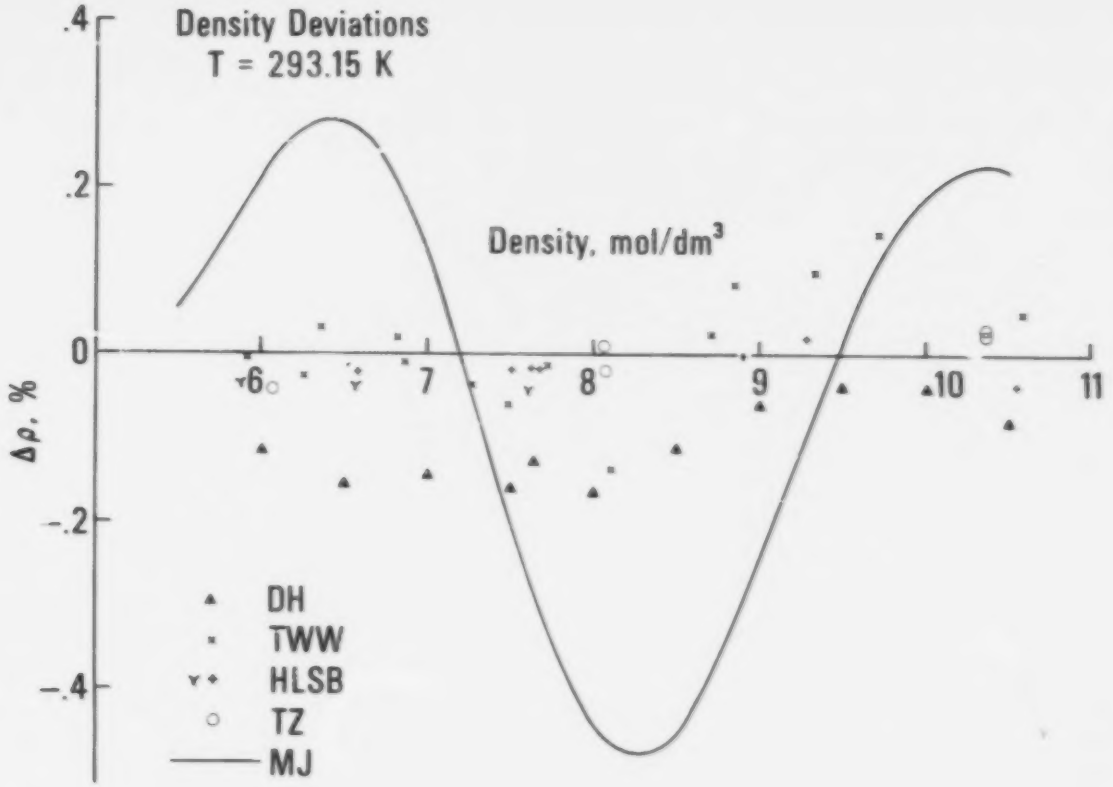

Fig. 4 As in Fig. 2, but at 293.15 K.

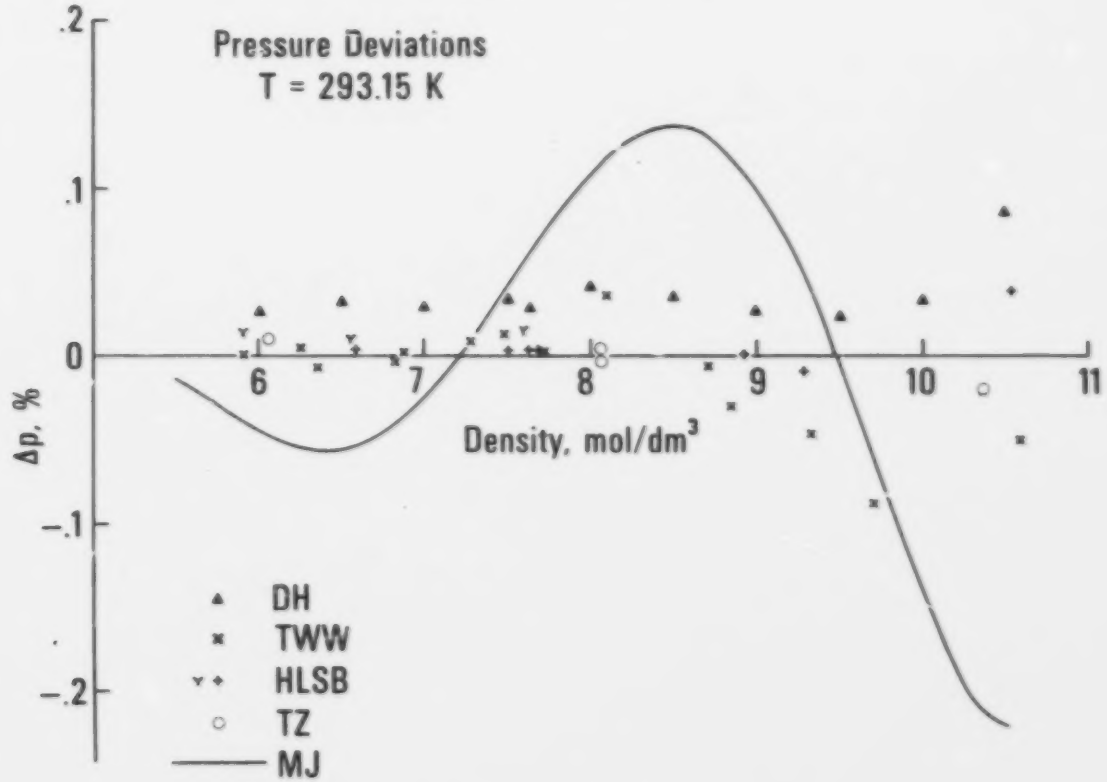

Fig. 5 As in Fig. 3, but at 293.15 K.

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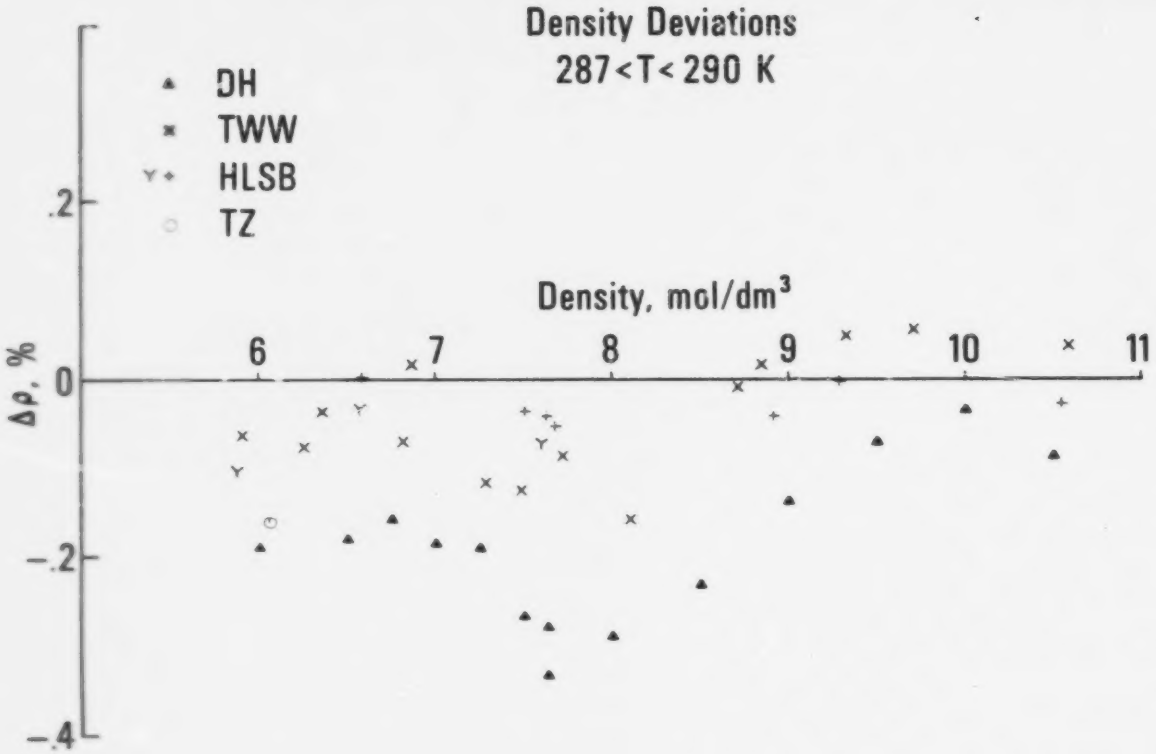

Fig. 6 As in Fig. 2, but for temperatures from 287-290 K.

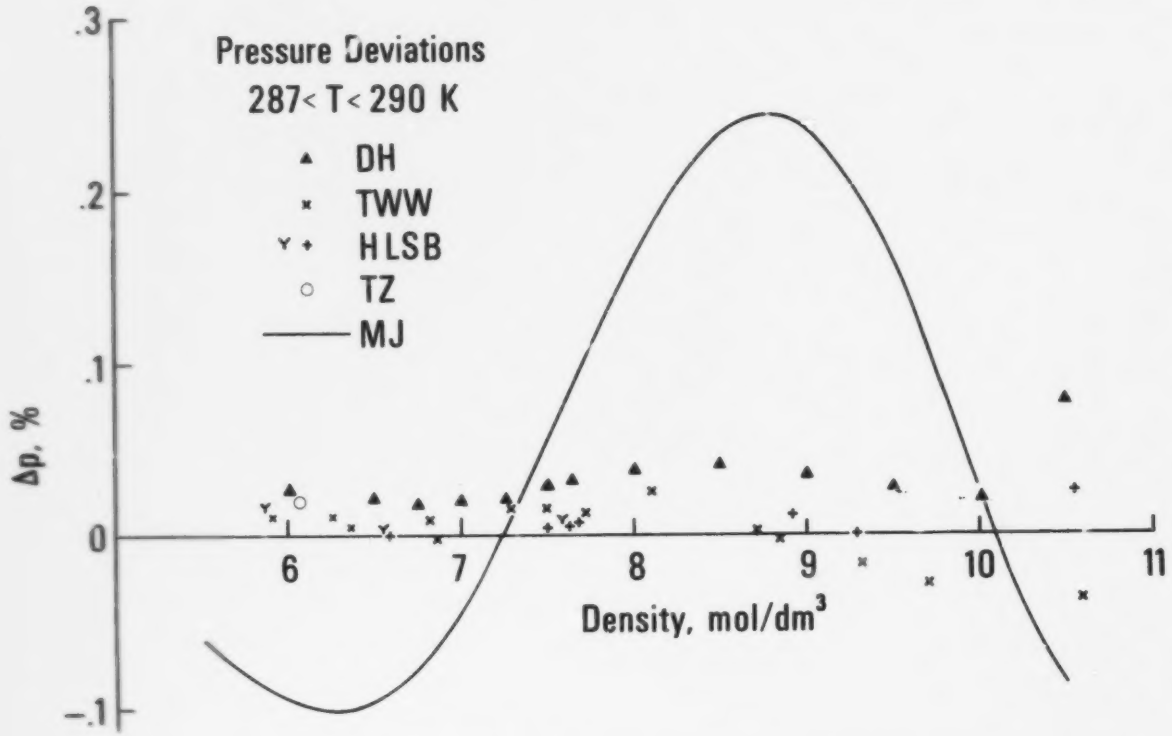

Fig. 7 As in Fig. 3, but for temperatures from 287-290 K.

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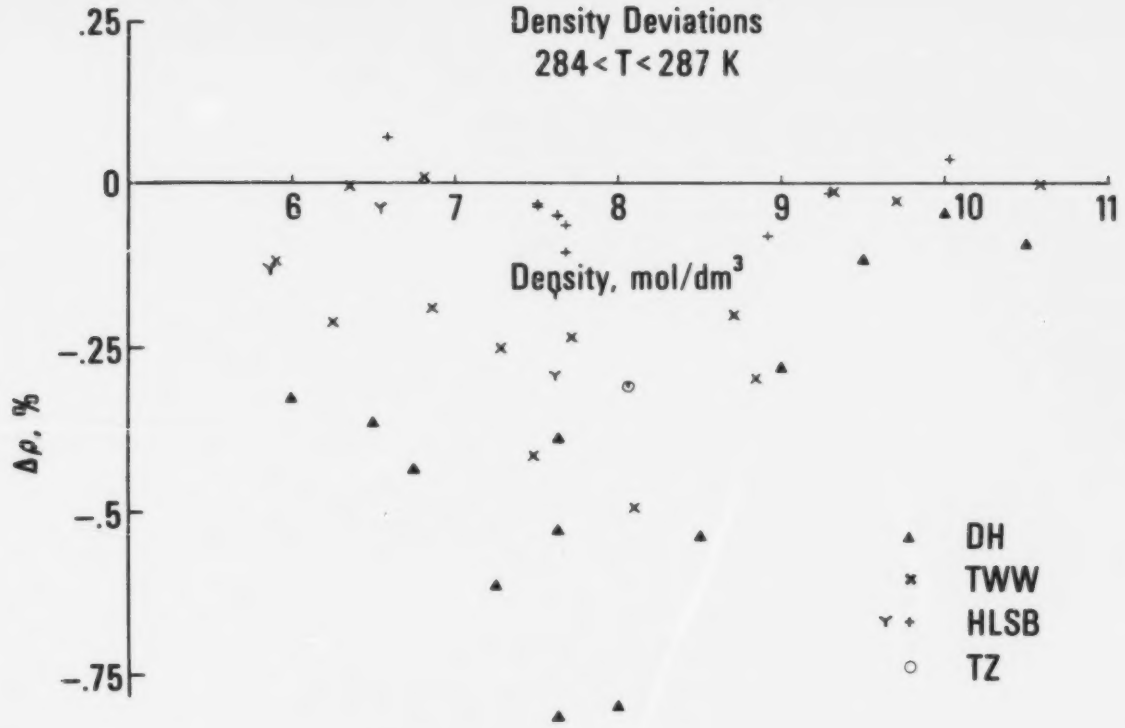

Fig. 8 As in Fig. 2, but for temperatures from 284-287 K.

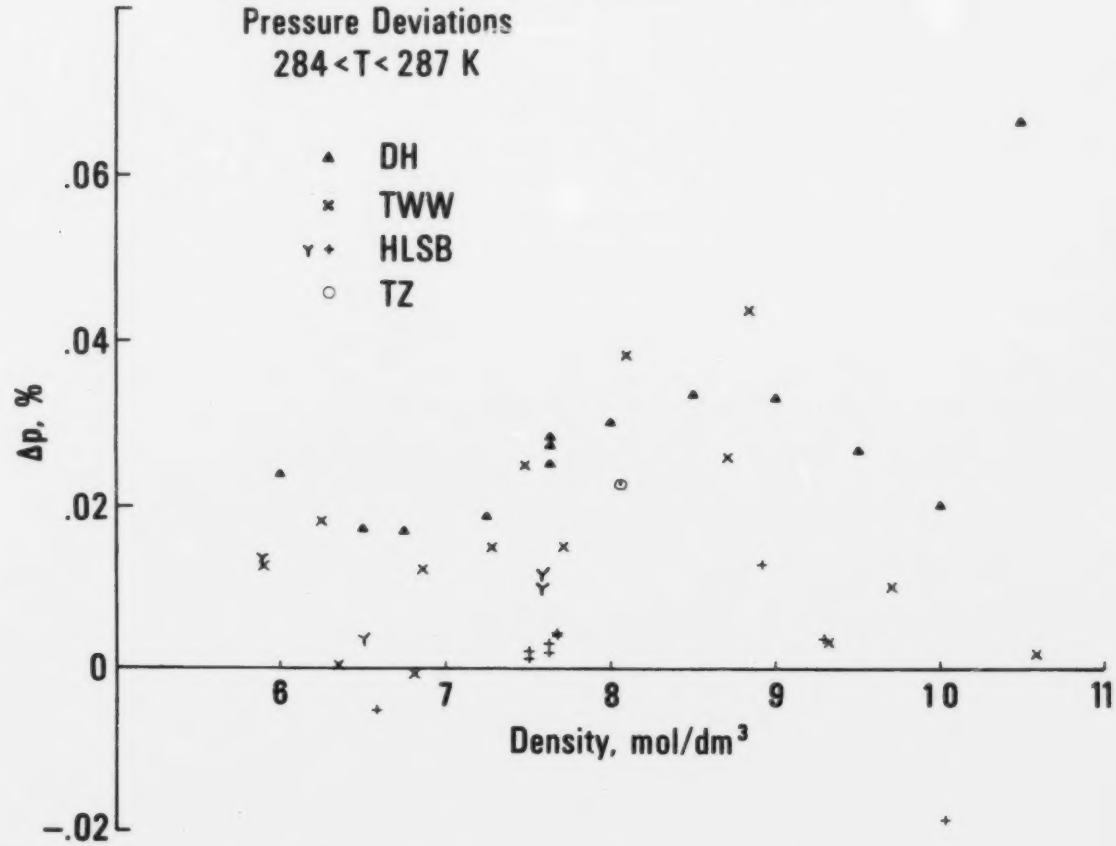

Fig. 9 As in Fig. 3, but for temperatures from 284-287 K.

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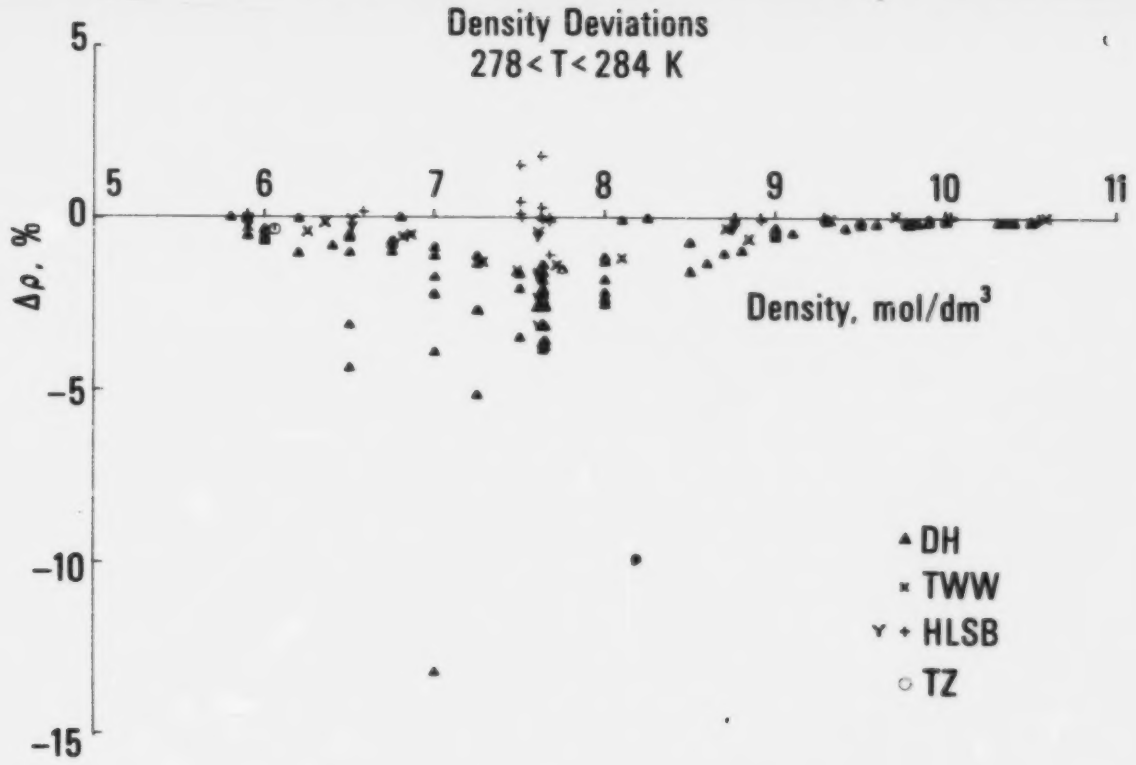

Fig. 10 As in Fig. 2, but for temperatures from 278-284 K, i.e., spanning the critical temperature. The large density departures between the different data sets are caused by the divergence of the compressibility and the expansion coefficient.

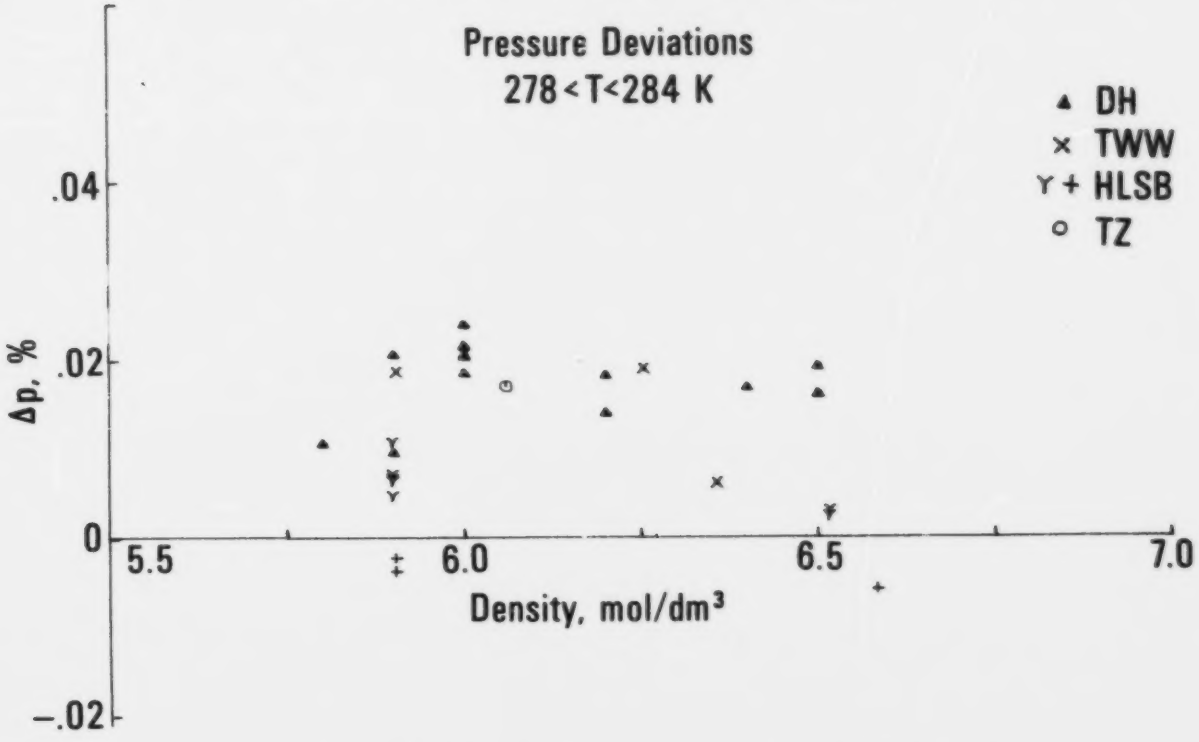

Fig. 11 Pressure deviations, in %, between experimental PVT data and the present formulation, if compared at the same density. The comparison is for the subcritical densities, 5.5-6.5 mol/dm³, and for the temperatures from 278-284 K. Symbols as in Fig. 2.

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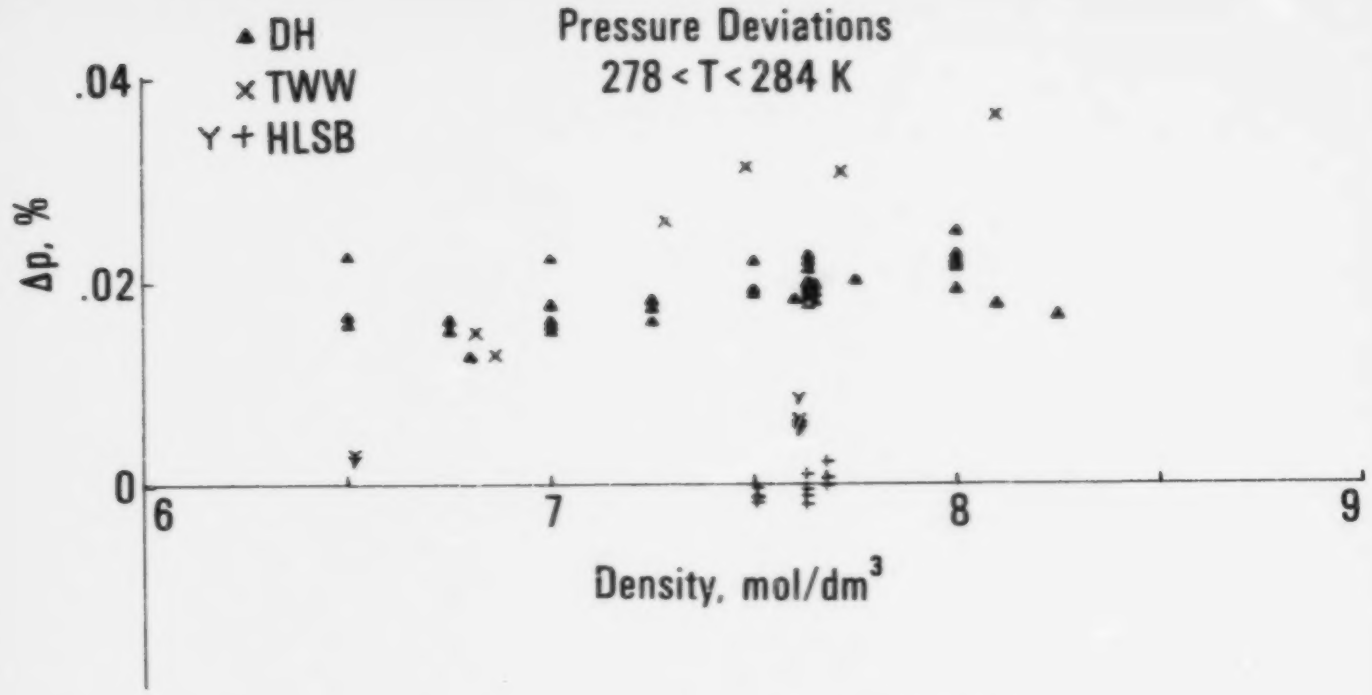

Fig. 12 As in Fig. 11, but for densities from 6.5-8.5 mol/dm³, i.e., spanning the critical density.

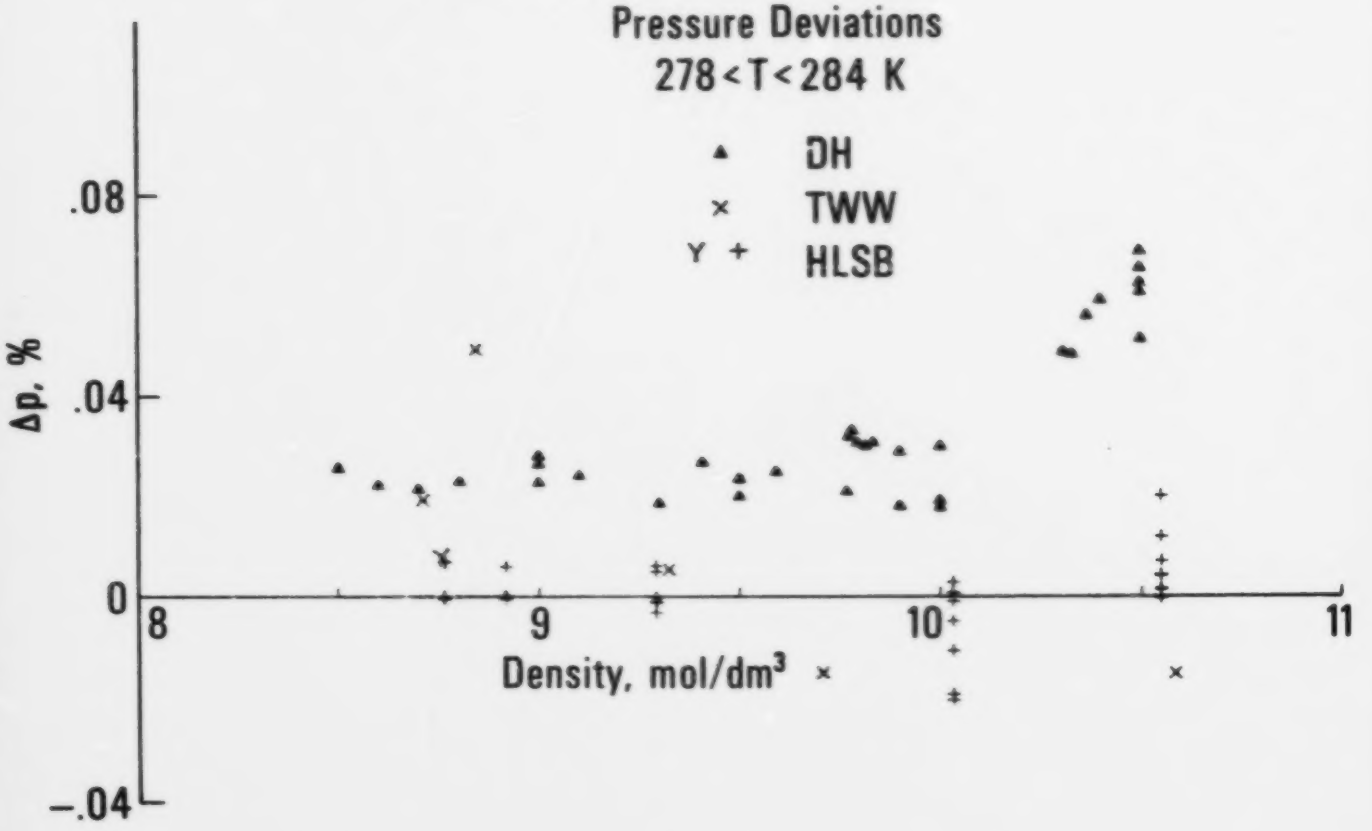

Fig. 13 As in Fig. 12, but for liquid-like densities from 8.5 - 10.5 mol/dm³.

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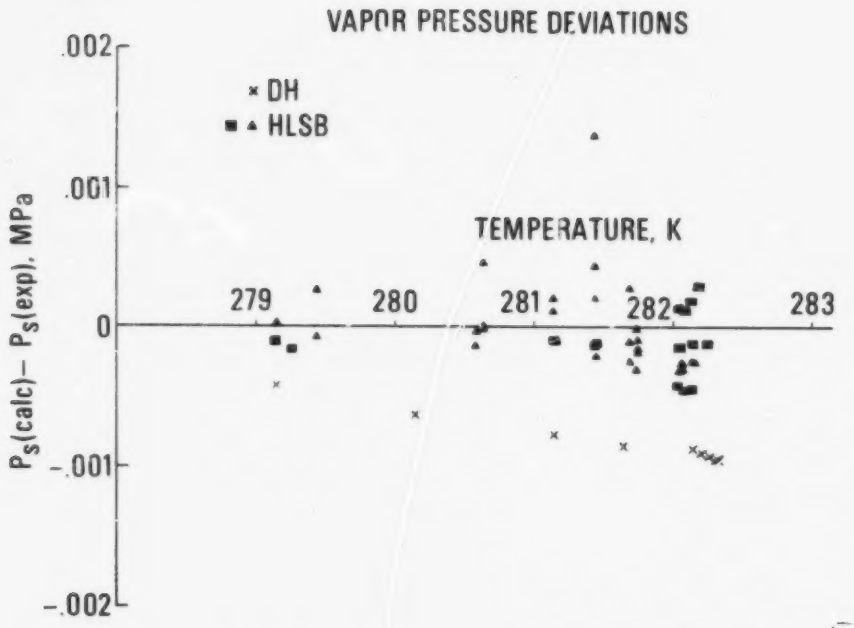

Fig. 14 Departures of the vapor pressures from the present formulation x DH [10]; ■ HLSB [3], 99.993% pure sample; Δ HLSB [3], 99.999% pure sample.

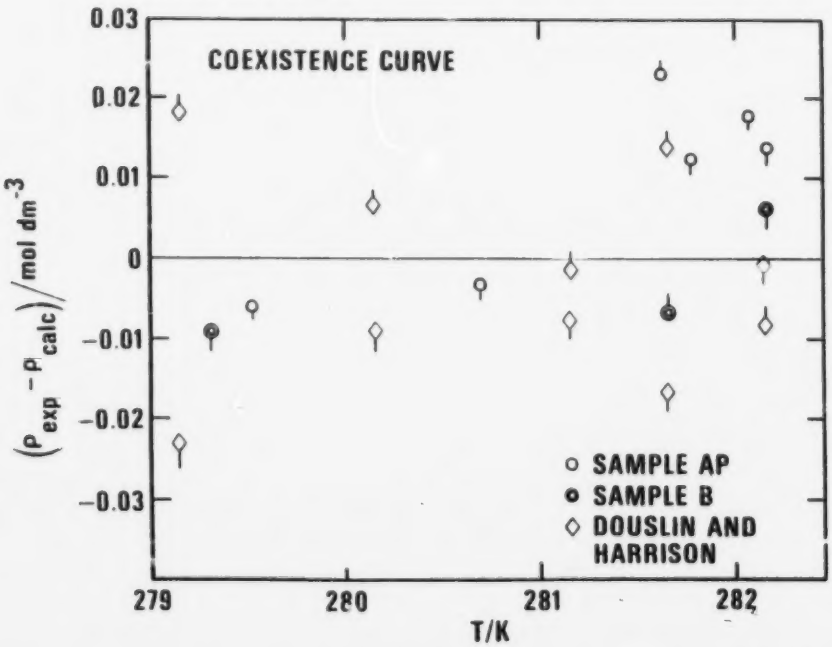

Fig. 15 Departures of the coexisting densities from the present formulation. Upward-pointing line segments denote vapor, downward-pointing ones liquid densities.
◆ DH [10]; o HLSB, 99.993% pure sample [3], o HLSB, 99.999% pure sample [3].

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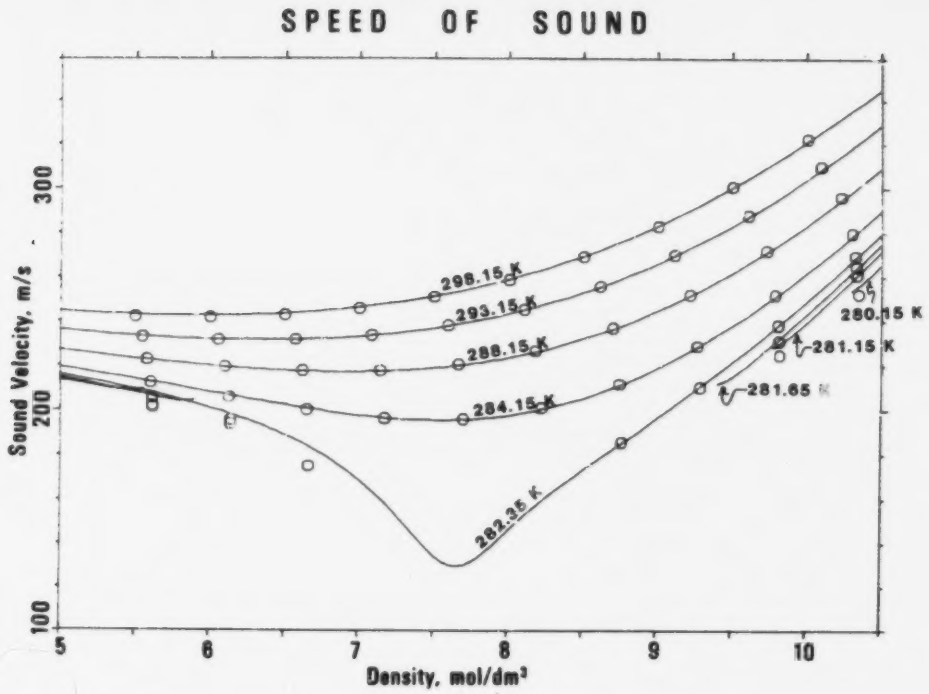

Fig. 16 The speed of sound as measured by Gammon [4], o, compared with full curves. Only below T_c very near the phase boundary do systematic differences exist.

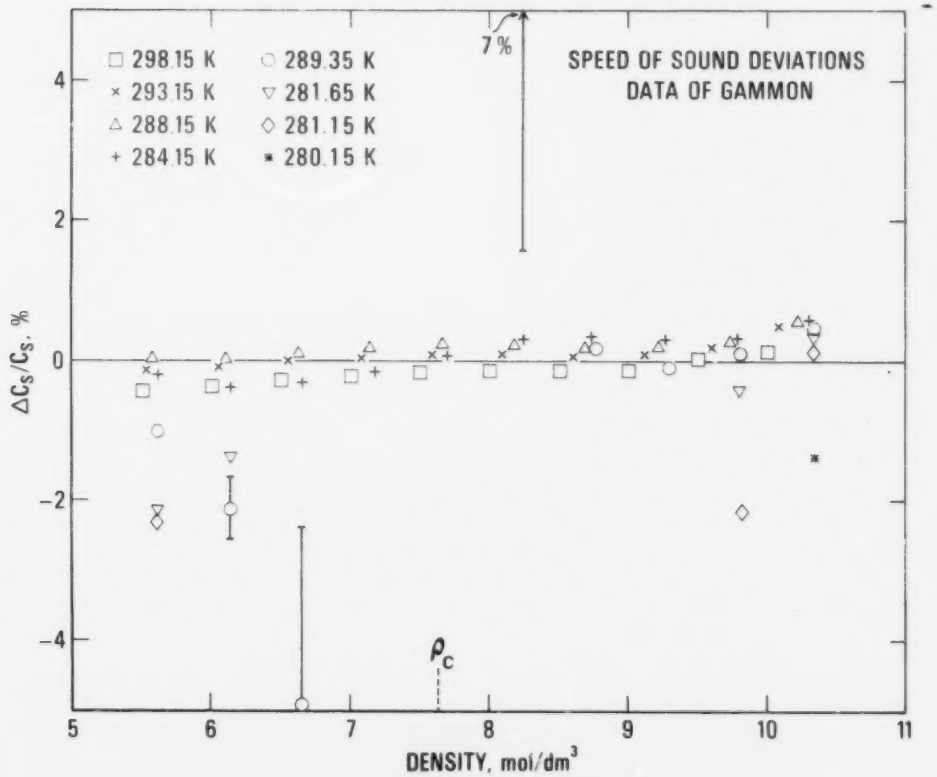

Fig. 17 Departures of the speed of sound data [4], in %, from the prediction of our surface. Some points have very large departures; their estimated error, however, is also quite large. Near the phase boundary, however, the departures of 1-2% are systematic and significant.

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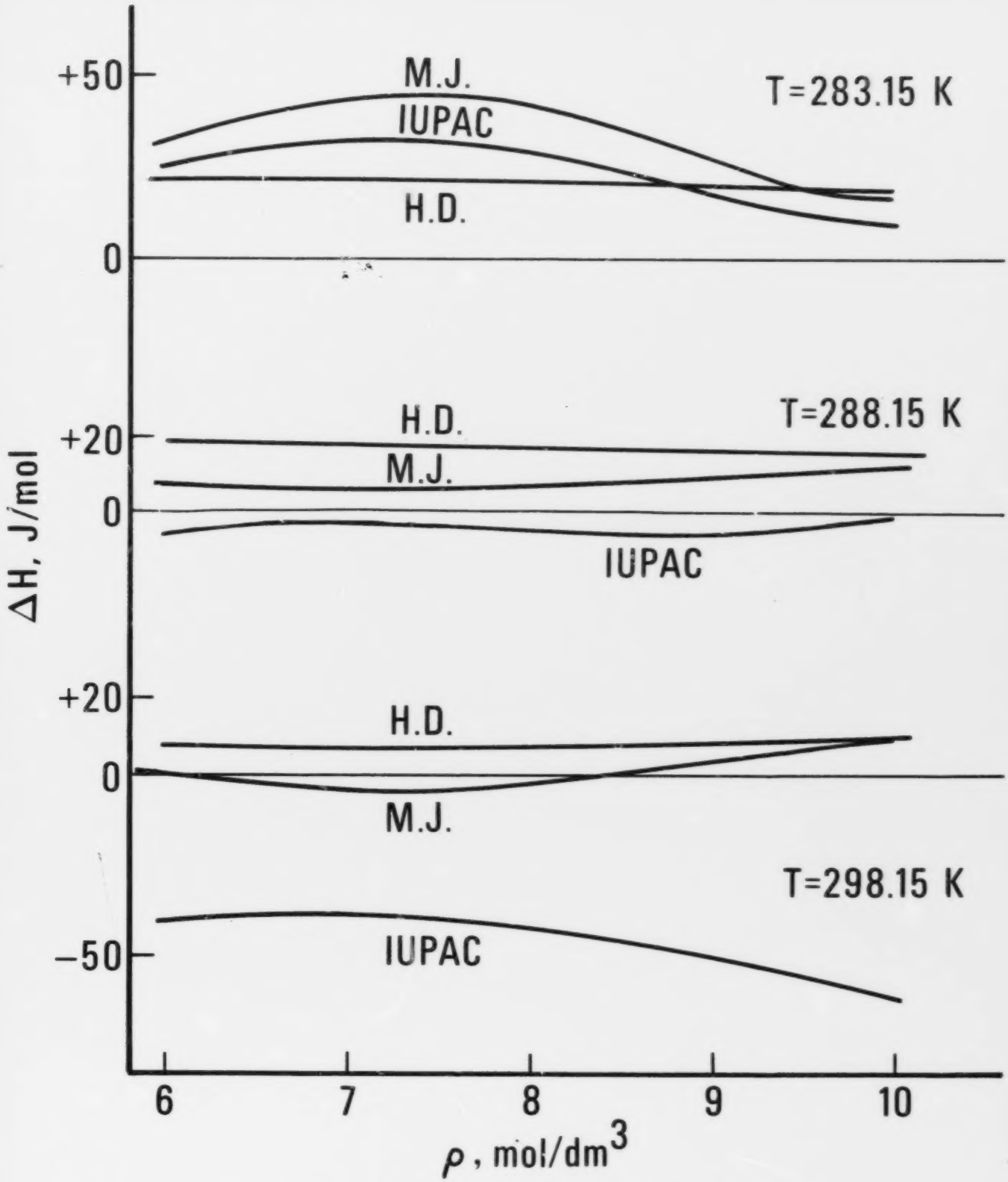

Fig. 18 Comparison of the enthalpies of ethylene according to various formulations. M.J. [5]; IUPAC [14]; HD [17]. The base line is the present formulation, which was anchored to that of M.J. at the state point 6 mol/dm^3, 298.15 K.

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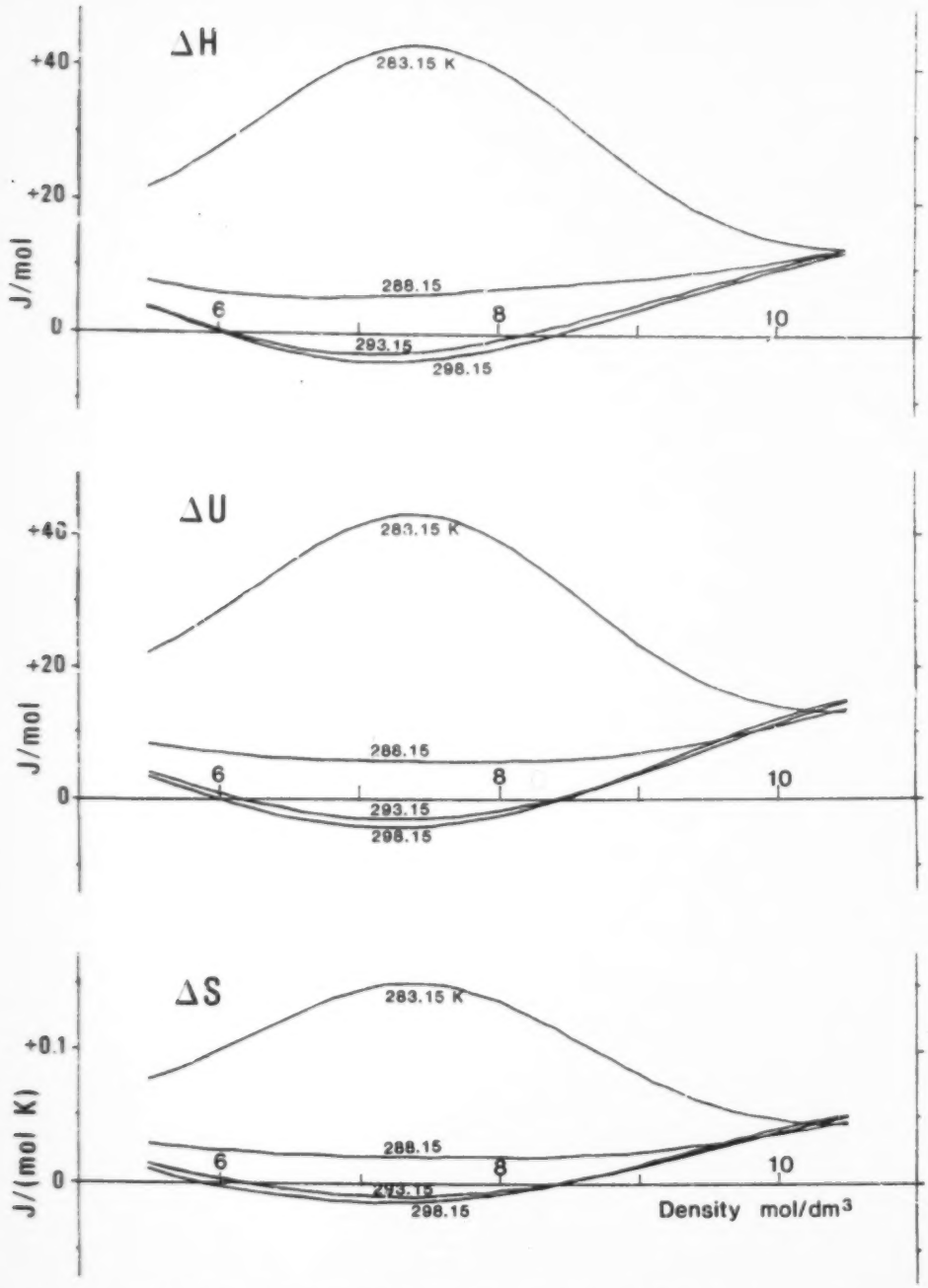

Fig. 19 The difference between the prediction of McCarty and Jacobsen for several thermodynamic properties and the present formulation. Top: enthalpy difference ΔH; center: energy difference ΔS. The M.J. formulation has a somewhat different density dependence than the present one. Substantial differences occur near the critical density and within a few K from the critical temperature.

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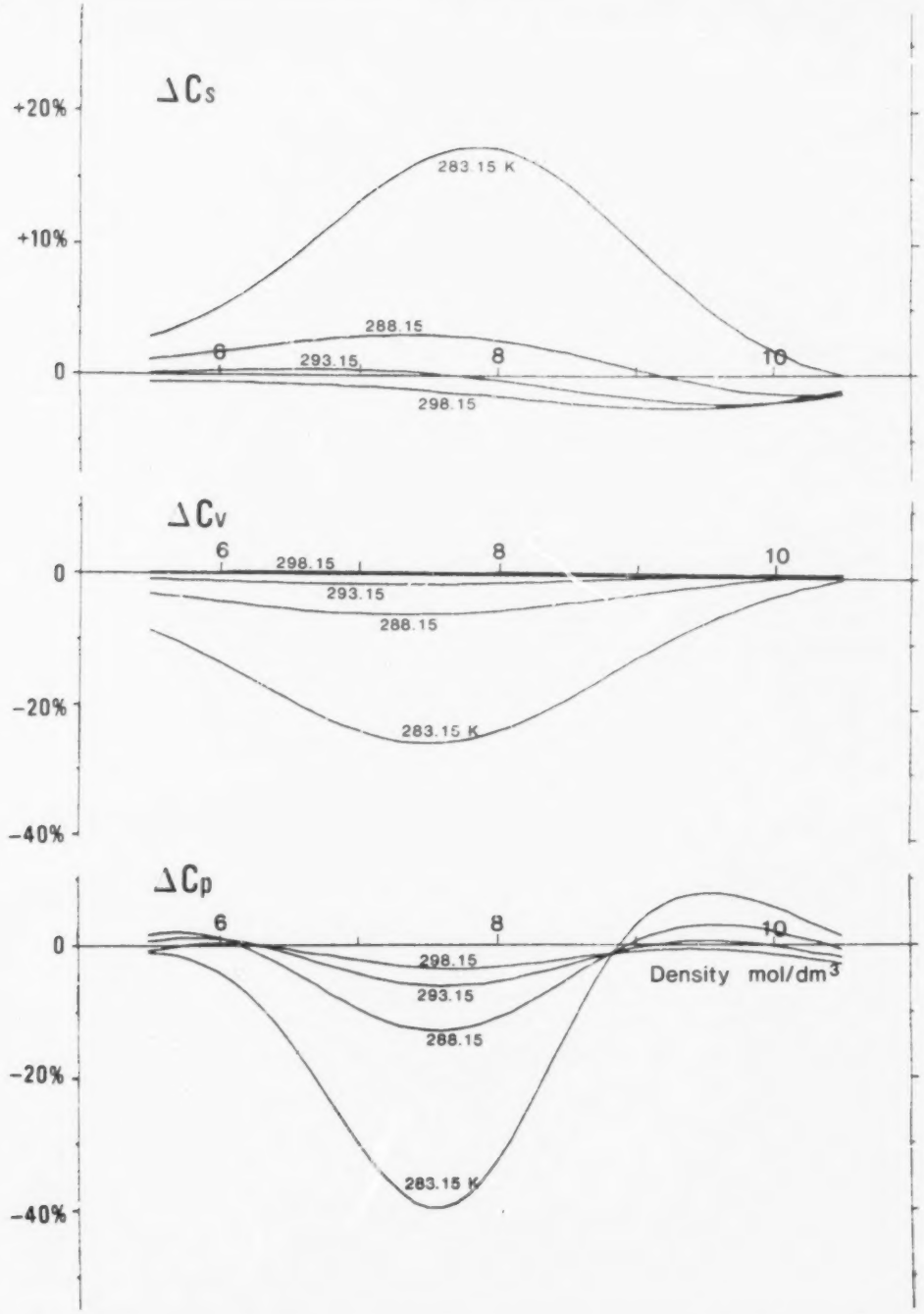

Fig. 20 The percentage difference between second-derivative values according to the McCarty-Jacobsen formulation and the present one. Top: speed of sound difference ΔC_s; center: difference in specific heat at constant volume ΔC_v; bottom: difference in specific heat at constant pressure ΔC_p. The differences between the two formulations are substantial within the range of 5 K from the critical point. The analytic formulation M.J. will have a non-zero thermodynamic speed of sound and a finite C_v at the critical point, while it underestimates the strength of the divergence of C_p.

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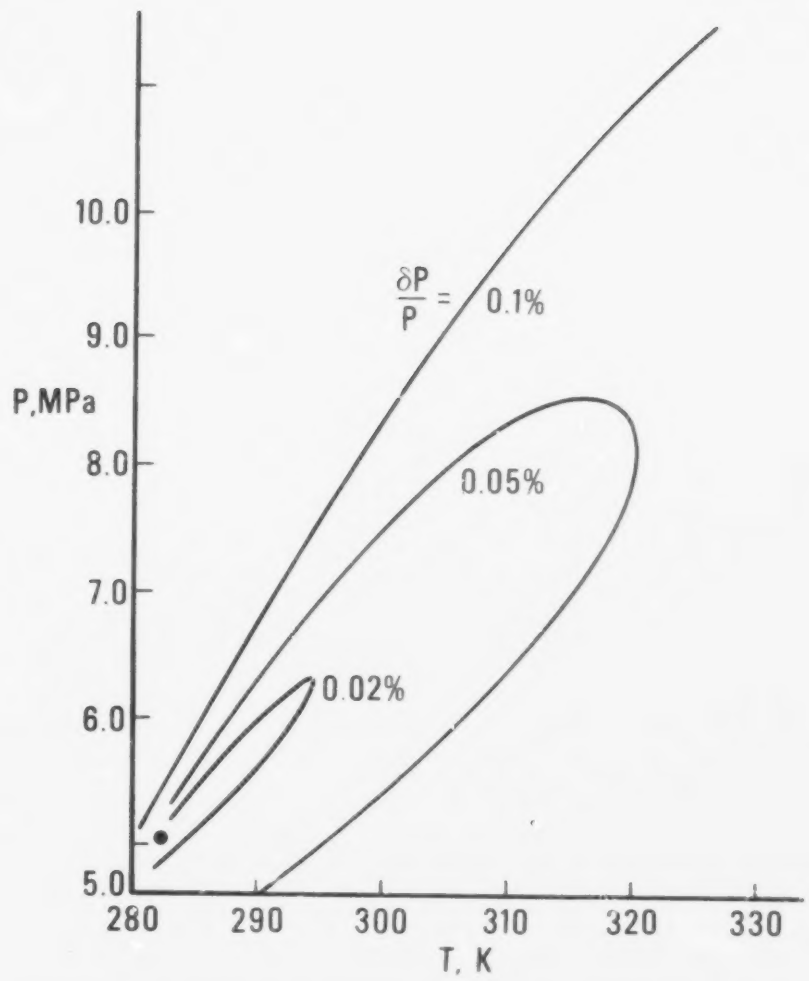

Fig. 21 The region of P-T space that should be avoided in custody transfer if the pressure is measured to, respectively, 0.1%, 0.05% or 0.02% and an accuracy of 0.1% is desired in density.

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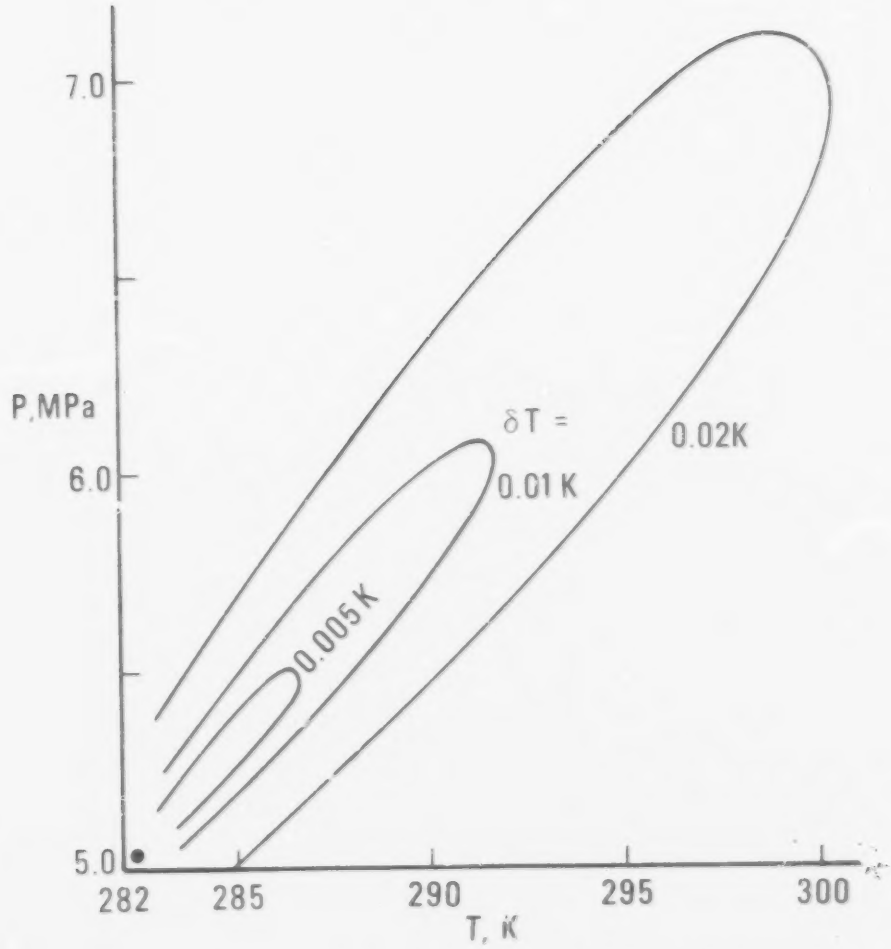

Fig. 22 The region of P-T space that should be avoided in custody transfer if the temperature is measured to, respectively, 0.1%, 0.05% and 0.02% and an accuracy of 0.1% is desired in density.

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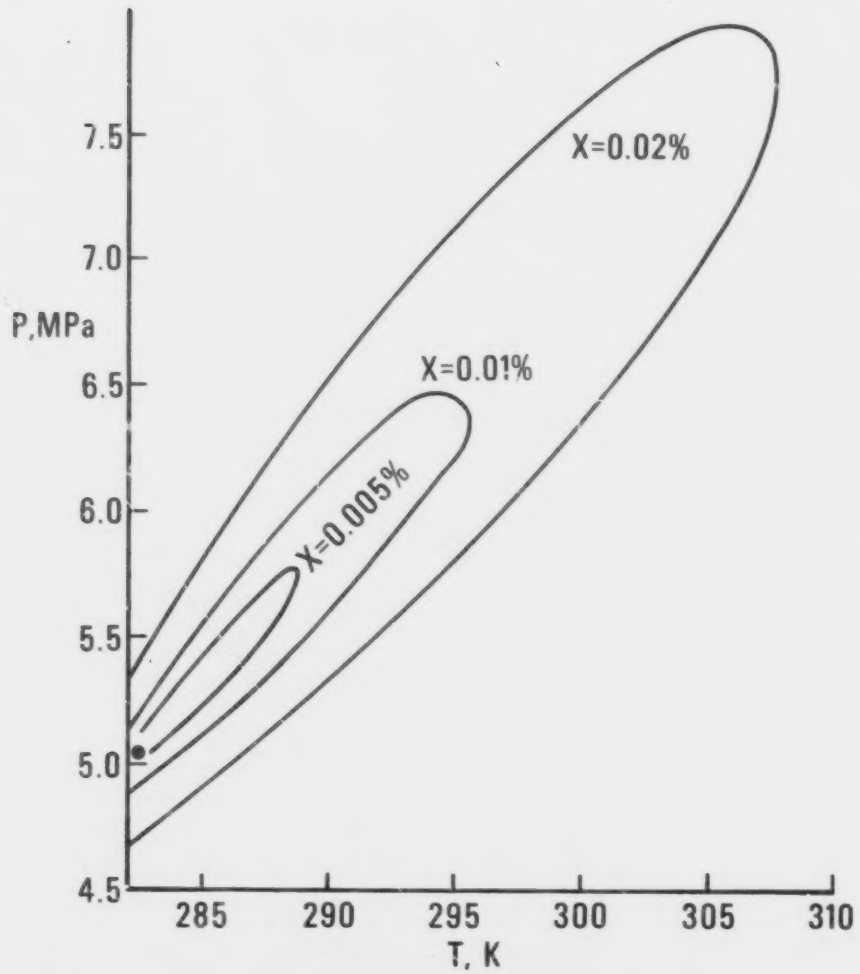

Fig. 23 The region of P-T space that should be avoided in custody respectively, 0.005%, 0.01% or 0.02% (in mole fraction) of an impurity very different in volatility from ethylene, is present, and an accuracy of 0.1% is desired in density.

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U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBS TN 1165	2. Performing Organ. Report No.	3. Publication Date October 1982

4. TITLE AND SUBTITLE

A Thermodynamic Surface for the Critical Region of Ethylene

5. AUTHOR(S)

J. M. H. Levelt Sengers, J. S. Gallagher, F. W. Balfour, and J. V. Sengers

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

Celanese Chemical Co., Cities Service Co., Continental Oil Co., Gulf Research and Development, Mobil Chemical Co., Monsanto Polymers and Petrochemicals Co., Phillips Chemical Co., Union Carbide Corp., and the National Bureau of Standards.

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program, SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

Tables are presented of thermodynamic properties of ethylene in the range 279-300 K in temperature, 5.75-10.5 mol/dm^3 in density, which range includes the critical point. The tables presented here are based on the critical-point scaling laws and incorporate the critical anomalies in a proper fashion. The tables thus complement the formulation of the equation of state of fluid ethylene by McCarty and Jacobsen (NBS Tech. Note 1045, 1981) which does not claim accuracy near the critical point. The predictions of the present formulation are compared with four sets of recent PVT data, and with speed-of-sound data. Tables are presented of pressure, energy, enthalpy, entropy, specific heats and speed of sound as function of temperature along finely-spaced isochores. The computer program required for table generation is included. Even if the surface were perfect, the reliability of densities calculated at experimental pressures and temperatures of limited accuracy declines rapidly as the critical point is approached. Contour plots in P-T space are presented of regions to be avoided in custody transfer for given uncertainties in pressure, temperature and sample composition.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

critical region; custody transfer; density; enthalpy; ethylene; equation of state; impurity; scaling laws; specific heat; speed of sound; tabular values; thermodynamic properties.

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